A MANUAL

OF

DENTAL PROSTHETICS

BY

GEORGE HENRY WILSON, D.D.S.

PROFESSOR EMERITUS OF PROSTHESIS AND METALLURGY IN THE DENTAL DEPARTMENT OF WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO; SPECIAL PROFESSOR OF PROSTHESIS IN THE DENTAL DEPARTMENT OF THE UNIVERSITY OF SOUTHERN CALIFORNIA, LOS ANGELES, CAL.

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THIS VOLUME

IS DEDICATED TO THE MEMORY OF THE LATE

JONATHAN TAFT, D.D.S., M.D.

AS A TOKEN OF RESPECT AND ADMIRATION FOR THE LIFE AND

WORK OF THE EMINENT TEACHER, PROFESSIONAL

MAN, AND CHRISTIAN GENTLEMAN

THE AUTHOR

PREFACE TO FOURTH EDITION.

THE author is grateful for the kindly reception of the former editions of this book, the many expressions of appreciation, and the reviews accorded them on both sides of the Atlantic.

The author is convinced that a New School of Dental Prosthetics is rapidly developing, and in this edition has given the present status of the New School, while in no way curtailing the generally accepted teaching of the Bonwill School. Chapter I has been extended to give the physics of the muscles and ligaments of mastication, thus laying a broad foundation for the New School.

Dr. Hall's theories have been revised by him.

Casting methods have been much enlarged, and it is believed presented in a logical, up-to-date, but conservative manner.

Roofless Dentures are treated in a trenchant, but practical way.

The investigations of Dr. Geo. B. Snow on shrinkage in vulcanization, and scientific vulcanization are given in this edition.

The motive of this book is: *much in few words.* The purpose is to give the technic clearly once, and to elaborate the underlying principle as much as may seem necessary. Therefore if a portion of the book seems to be devoid of technical descriptions it is because the text being read is an

elaboration of a principle, a suitable technic for which will be found previously stated, but in sequential order.

The book is designed for both the busy student and practitioner; therefore in addition to the standard instruction in methods and materials the recent methods and materials are presented and discussed, but without prolixity.

The author wishes to express his thanks to Drs. George B. Snow and Rupert E. Hall for permission to present their valuable work; also to his publishers for their always courteous and helpful attitude.

George H. Wilson.

Cleveland, Ohio, 1920.

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PROSTHETIC DENTISTRY.

CHAPTER I.

THE MOUTH.

THE mouth, from an anatomical point of view, is the entrance to the alimentary canal; and primarily is for receiving and preparing the food for deglutition. In mankind there is a secondary use, that is, to aid in speech and expression. In this chapter the mouth will be considered only in its primary relationship; its secondary function will be treated in the chapters on Cleft-palate and Esthetics.

ANATOMY.[1]

The face is divided into three portions, known as the first portion or upper third, second portion or middle third, and third portion or lower third (Fig. 1). These thirds are indicated by four imaginary and approximately parallel lines—the first at the top of the forehead, or normal hair line; the second at the junction of the forehead and nose, or a line

[1] It is not within the province of this monograph to treat in detail either general or dental anatomy; it considers only their practical application. It is assumed that the student has some knowledge of the tissues and organs under consideration; and it is hoped that the practically applied anatomical science will create a desire for an intimate acquaintance with the subject.

The student is referred to his text-books on general and dental anatomy, and especially to the excellent article, "The Human Dental Mechanism: Its Structure, Functions, and Relations," by Charles R. Turner, M.D., D.D.S., in the third and fourth editions of the American Text-book of Prosthetic Dentistry.

For convenience of expression, the singular form of the names of bones and muscles is used, although, with few exceptions, they are in pairs. One side of the cranium is a counterpart of the other.

drawn at the lower border of the crest of the supraorbital ridges; the third at the base of the nose and extending from the anterior spine of the maxilla to the lower border of the external auditory meatus; the fourth line at the lower border of the chin. In passing it may be noted that in the ideal Greek face these thirds are of equal length, but in

FIG. 1

nature they vary greatly. These lines, however, are very important in the study of the face, for they determine the proportions—whether or not the face is well balanced.

Plane of the Teeth.—The third line (Camper's line), or the naso-auditory meatus line, is of importance in marking or indicating the plane of the upper twelve anterior teeth (Figs.

1 and 2). It should be noticed that the teeth plane is a straight plane extending from the mesial angle of the upper central incisor to the distobuccal cusp of the first molar; also that the teeth plane indicates approximately one-third of the distance from the third to the fourth face line. The teeth plane may be extended backward and it will be seen that the

Fig. 2

second and third molars are progressively stepped upward. Attention has but recently been called to this fact, so, to satisfy himself of the truth of the statement, the student should not only notice the few illustrations given (Figs. 1 to 6), but he should observe every normal or nearly normal skull and plaster cast of teeth that opportunity may present. The straight line from the crest of the cusp of the upper cuspid

tooth to the crest of the distobuccal cusp of the first molar is assumed by the author to be the foundation of the formation of the dental arch; and the other teeth in the arch are in compensating positions. The four teeth—cuspid, first and second bicuspids, and first molar—of an artificial denture

Fig. 3

may always be placed in this straight line and be considered anatomically normal and mechanically correct.

There is a reason for these four teeth being in a straight line and considered as the foundation of the dental arch. By referring to Fig. 1 it will be seen that the portion of the

Fig. 4

maxilla in which these four teeth are located has a massive cubical block formation, and that the remaining teeth are in extensions of this cubical block. The cubical block is outlined by the frontonasal column *A B*, the zygomatic column *C G D*, the infraorbital arch *B F D*, and the molar

arch *A C*. The incisors are in the lower nasal arch *A E*, a forward extension of the cubical block; and the second and third molars are in a tuberosity extending backward from the cubical block. (A cube has the strongest formation and the greatest resistance to force because its dimensions

Fig. 5

are equal in each direction.) This formation is suggestive that the force of mastication should be upon the area of this cube, and that the straight formation has the greatest resistance to a displacing force applied to an artificial denture.

The scheme presented in this book for antagonizing complete dentures is based upon this fundamental principle.

Fig. 6

Curve of Spee.—The curve of Spee should be located and thoroughly understood. The curve of Spee is an imaginary one, and is described as a segment of a circle which begins with the incisal edges of the lower incisors, passes over the crest of the buccal cusps of the lower bicuspids and molars,

and ends in the anterior border of the condyloid process (Fig. 7[1]). The degree of curvature of this curve of Spee will depend upon the angle of inclination of the articular tubercle (Fig. 2, *G*). For some years writers and teachers have made this curve of Spee (theoretically) the fundamental principle in the anatomical arrangement of the teeth; and a very elaborate and complicated system of "articulation" has been evolved from it.

Compensating Plane.[2]—This term has been used as synonymous with the curve of Spee. It should not be so used, for the curve of Spee belongs entirely to the mandible, and

FIG. 7

is anatomical; while the compensating plane is mechanical. The compensating plane (as produced for mechanical reasons) is rarely ever found in nature; but may be used in complete artificial dentures. The compensating plane is that arrangement of the teeth whereby the so-called three-point contact is established between the upper and lower artificial dentures. If this plane is to be of any practical value, it must be in harmony with the excursions of the condyle. If the articu-

[1] Fig. 7 from a photograph of a specimen in the Wistar Institute of Anatomy.

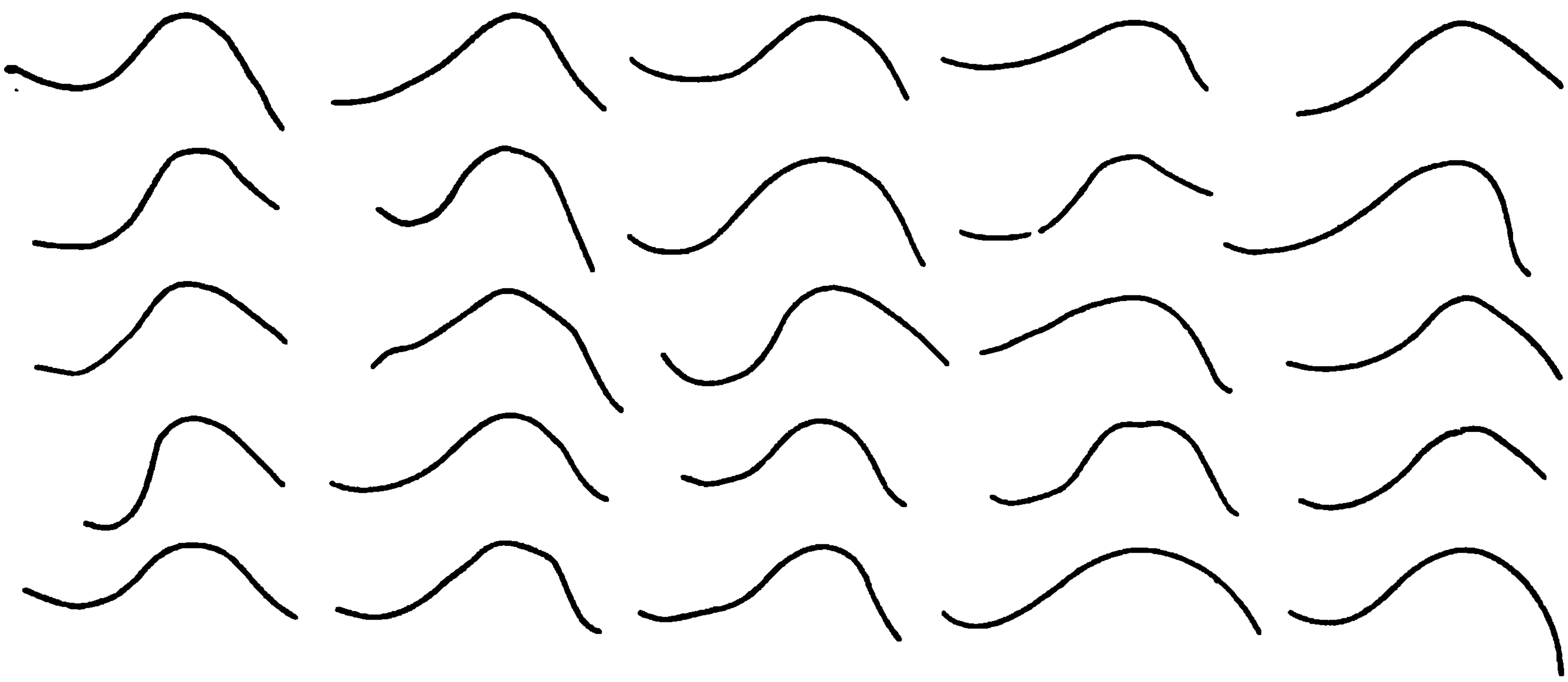
[2] Dr. Amoedo, Emeritus Professor of the Dental School of Paris, proposes the term compensating plane in place of compensating curve. It seems to the writer to be a much better term.

lating surface of the articular tubercle is horizontal, the condyle moves straight forward in its excursions, and no compensating plane to the teeth plane is required; but if this articulating surface is oblique the condyle must also descend when it moves forward. However, it should be noted that the beginning of the downward inclination of the tubercle is gradual, and that the upper incisors overlap the lower incisors one-third the length of the crown of the tooth, and that the one-third overlap represents a segment of a circle of 3 degrees. As the head of the condyle will travel forward in a straight line approximately 4 mm., therefore the straight condyle path of the Bonwill, Snow and Hall antagonizers are anatomically correct, and no measurement or special mechanism is required; however, if for esthetic reasons the upper incisors are to be protruded beyond the lower more than 4 mm. then the inclination of the articular tubercle must be taken into consideration. This can best be done in the mouth while the artificial teeth are attached with wax.

Temporomandibular Articulation.—This is a condylarthroidal joint, the structures taking part in it being the mandibular fossa of the temporal bone and the condyle of the mandible, together with the ligaments and the tissues interposed between the bones.

The mandibular fossa (Fig. 2, *F*) is an oblong cavity on the under surface of the squamous portion of the temporal bone, its concavity being directed downward. It is bounded anteriorly by the articular tubercle, externally by the middle root of the zygoma and the auditory process and posteriorly by the tympanic plate of the petrous portion of this bone. The anterior two-thirds of this fossa is smooth, and covered, in the recent state, with a dense fibrous tissue, and receives the condyle of the mandible. Of the articular portion of the fossa the distal part is the most concave, and is also the most elevated. From this point it slopes downward and forward to the crest of the articular tubercle, furnishing a surface over which the condyle glides in the forward excursions of the mandible. The shape of the cavity varies with different nationalities, with different individuals, and sometimes with the opposite side of the same individual.

The principal variations are, in size and general concavity, in correspondence with the shape of the condyle, in extent of the surface from the most concave portion of the articular tubercle, and in the inclination. The outlines in Fig. 8[1] show the curve of its cavity obtained from skulls after the method of Tomes and Dolamore. The fossa alters frequently in old age, from the pull of the muscles upon the mandible in trying to bring into occlusion teeth that may be widely separated in location.



A *B* *C* *D* *E*

FIG. 8.—Outlines of mandibular fossæ obtained by the method of Tomes and Dolamore. The heavy base line is parallel to a line drawn from the anterior nasal spine to the floor of the external auditory meatus. All the fossæ outlines were on the left side of the skull: *A*, from skulls with typical dentures; *B* and *C*, from skulls with several teeth missing; *D* and *E*, from edentulous skulls.

The condyle of the mandible (Fig. 2, *H*) is the distal upper extremity of the ramus, which fits into the mandibular fossa. The head is an elongated oval body, with its long axis at nearly right angles to the ramus. The head of the condyle is separated from the ramus by an elongated neck, about which strong ligaments are attached, connecting the mandible with the temporal bone. The head is separated from the

[1] Turner's American Text-book.

mandibular fossa by a series of tissues that act both as a cushion and a lubricated gliding surface. By this peculiar formation various movements are made possible. The mandible may be carried bodily forward by unison in the movement of the condyle upon either side of the cranium. Whether this movement is horizontal or oblique will depend upon the formation of the eminentia articularis. If one condyle only is moved forward the other will rotate upon its variable axis, showing the ball-and-socket formation. Mr. Norman G. Bennett, of England, has recently described a third movement of the mandible in which it moves bodily laterally. By this movement all of the buccal cusps of either side of the mouth are brought evenly in contact in the process of mastication. It is the action of the powerful muscles of mastication that makes it impossible to absolutely reproduce the movements of the mandible upon a mechanical frame; nor is this necessary, because the joint is a remarkably adaptable one, and, to an extent, conforms to the demands made upon it. The movements of the condyle may be in any direction, but more freely in some directions than in others. The forward movement is the freest and the important one in prehension (seizing or grasping—as of food), but the lateral mandibular movement is the important one of mastication. The distal movement of the condyle is usually quite restricted, but there are a few instances in which the distal movement from the normal rest position is excessive and perplexing.

The Mandible.—This is the preferred name for the lower jaw (Fig. 2). It is often called the inferior maxilla, but this name is becoming obsolete. The mandible is the largest and strongest bone of the face, and serves for the reception of the lower teeth. It consists of a curved horizontal portion, the *body* (Fig. 2, *J*), and two perpendicular portions, the *rami* (Fig. 2, *I*), which join the back part of the body at nearly right angles. The mandible is the movable portion of the dental armament, therefore it is of special interest to the dental student, because of its use and the changes that take place with the loss of the teeth, and, with old age. Because of its position it is subject to serious accidents and disease, namely, luxations, fractures, and necrosis. The large muscles of mastication are principally attached to the rami,

and the condylar articulation is the only attachment of this bone with the cranium. It has been considered that the mandible is a lever of the third class. This is undoubtedly a misinterpretation of the physics involved, and will be considered under the heading: Physics of the muscles of mastication and the temporomandibular joint. The length of the muscles is necessary to permit freedom of movement, and their great strength to make possible the easy performance of the work for which they are designed. That much power is necessary for masticating food can easily be surmised by observing the powerful grip of those animals whose dental armament is not designed for offence and defence. This is well illustrated in the horse, whose small mouth opening prevents the grasping of objects between the molar teeth; but with its incisors it may, in a fit of rage, grip and shake a large man or an animal, weighing two or three hundred pounds, as a small terrier would a rat. The power required for man to masticate his food has been experimentally measured by both Professor Black and Dr. Head. Professor Black found that some articles of food require from forty to eighty pounds of force to crush them, while the highest figure obtained by Dr. Head was forty-three pounds.

Ligaments.[1]—The movements of the condyle are limited not only by the form of the fossa but by ligaments. There are three ligaments—the stylomandibular, sphenomandibular and temporomandibular.

The first two named are long ligaments extending between the parts named, and their function is largely suspensory. Anatomists have disagreed upon the function of these ligaments of the mandible. It has been considered that in the opening movements of the mouth the mandible rotated from the insertion of these ligaments, that is, about the mandibular foramina, and some of the anatomical antagonizors have been constructed upon this supposition; fortunately this supposition made no practical difference. That the mandible rotates from the insertion of these ligaments is questioned; for the stylomandibular ligament extends downward and forward from the styloid process to the angle

[1] See Figs. 309, 310 and 311, Gray's Anatomy, 20th ed.

of the mandible, and if it were taut enough so that the condyle could rotate forward and down the articular tubercle the ligament would be so taut that the mandible could not move bodily forward as it is evident it does when the lower incisors are placed in front of the upper ones.

The capsular ligament is composed of short fibers extending from the periphery of the mandibular fossa to the cervix of the condyle. It is taught that the external lateral (or the temporomandibular) ligament is the thickest, strongest and most important portion of the capsular ligament. That it has a broad attachment to the zygoma and extends obliquely downward and backward to the neck of the condyle. That it permits considerable lateral movement of the condyle, but in the opening movement of the mouth the fibers will, when the teeth are a short distance apart, be made taut, and then the cervical attachment must act as a fulcrum over which the head of the condyle is thrown forward and downward upon the articular tubercle. Therefore the pivotal center of the opening movement of the mouth, after the first one-fourth inch space movement, is at the cervix of the condyle. Furthermore, the pivotal center of the first one-fourth inch opening movement and the last one-fourth inch in closing is at the center of the head of the condyle. Hence it is a logical conclusion that the pivotal center of the condyle only is of importance in mounting artificial teeth because no movements of the mandible can influence antagonization of the teeth until at least two opposing cusps touch, and no two cusps can occlude when the external lateral ligament (temporomandibular) is acting as a fulcrum.

The preceding paragraphs present two interpretations of the functions of the temporomandibular ligaments. The writer has been convinced by his study of the work of Prof. H. J. Prentiss, of the University of Iowa, and of Prof. Edmond Souchon, of Tulone University, New Orleans, that the temporomandibular ligament, as so clearly shown in most of the standard text-books of anatomy, rarely, if ever, exists in nature; therefore, is of no importance.

The whole head of the condyle is free to move in any direction limited only by the walls of its fossa and capsular

ligament. Its movement is further enhanced by the interfibrocartilage (articular disk) and two bursæ.

Muscles.—Muscles are bands or bundles of contracting fibers with two or more attachments. At least one of these attachments may be considered as fixed or stationary. The function of a muscle is to produce motion. The motion is produced by the contracting fibers drawing its movable attachment toward its fixation. As the direction of the force of a muscle is always between its attachments, it must have a counter, because a muscle fiber can produce but one action. Its power is in its contraction. There is no active power in the relaxing of the contracted muscle fiber. There are several groups of muscles attached to the mandible, namely, muscles of mastication, auxiliary muscles of mastication, and muscles of expression.

The temporal, masseter, external and internal pterygoid are classed as the muscles of mastication. They are arranged in symmetrical pairs, and usually operate simultaneously in the movements of the mandible, although each is capable and are the powerful elevators of the mandible. It is through the various inclinations of these muscles, acting in various combinations, that the mandible is protruded, retruded, and rotated. The depression of the mandible is by a different and a much less powerful set of muscles. The depressors of the mandible are the platysma myoides, digastric, mylohyoid, and geniohyoid muscles.

The auxiliary muscles of mastication consist of the buccinator and the composite muscle—the tongue. So far as the functions of these muscles concern the act of mastication, they are auxiliary to the muscles of mastication, and their use is to keep the bolus of food between the teeth. The buccinator (bugle blower) muscle should be given careful consideration, because its origin and insertion are such that it may seriously interfere with the stability of artificial dentures. Its origin is at the union of the alveolar process with the body of the maxilla. It begins in the proximity of the cuspid (canine) fossa and extends backward to the maxillary tuberosity. It is inserted in the corresponding portion of the mandible, or along the external oblique line. When the teeth have been lost and there is excessive resorption of the

alveolar processes, the attachments of this muscle may be very close to the crest of these resorbed processes. In such a case the contraction of the muscle in placing the bolus of food between the teeth tends to causing irritation of the soft tissues, especially if the buccal flanges of the base-plates are too deep. Sometimes, through carelessness or at least accidents in extracting, and through improper or no after-treatment, false attachments of the muscles are formed upon the process. These cases require that the flanges of the base-plate shall be cut away so as not to impinge, otherwise the false attachment must be surgically removed.

While the function of the tongue, as an auxiliary masticating muscle, is to keep the bolus of food between the teeth, there are a few of its component muscles that need consideration. The mylohyoid is attached to the whole length of the internal oblique line, and forms the floor of the mouth. Sometimes, through excessive resorption, the attachment of this muscle and the crest of the alveolar ridge are in such close proximity that there can be almost no lingual flange to the base-plate of an artificial denture, while with other conditions an extensive lingual flange may be used advantageously.

The geniohyoglossi are attached to the genial tubercles upon either side of the median line. These muscles form not only an important part of the tongue, but their genial attachment, in excessive resorption of the process, forms a serious obstacle to the stability of a lower artificial denture. The union of the anterior borders of these muscles, with its mucous membrane covering, forms the frenum linguæ. In no case should an impingement of the lingual flange of the base-plate upon the frenum be permitted. Upon the end of the body of the mandible, that is, at the union of the body with the ramus, is found the mandibular attachments of the superior constrictor of the pharynx. This, and the distal border of the buccinator muscle, in conjunction with the tubercle formed as the result of the resorption of the alveolar process, indicate the extent to which a lower denture may be worn distally. The distal border of the buccinator not only passes between the maxilla and mandible, but also sends some fibers to the pterygomaxillary ligaments. It is these fibers, with their mucous membrane covering, that form the

cord-like tissue extending posteriorly from the hamulus of the pterygoid process of the sphenoid and the corresponding location on the mandible, posterior end of the mylohyoid line of the mandible. The base-plates must be properly adjusted to this tissue, as it may dislodge the artificial dentures, and also may become very sore.

The muscles attached to the anterior external surface of the mandible are muscles of expression. Their location may affect the retention of an artificial denture, therefore we will now consider them from this view-point. Beginning on either side of the symphysis and extending outward, there are the three muscles, levator labii inferioris, depressor labii inferioris, and depressor anguli oris. These muscles arise at and below the union of the alveolar process with the body of the mandible. In excessive resorption of the process these attachments are so near the crest of the alveolar ridge that very little surface is afforded as a seat for a base-plate. However, the base-plate must be so formed as to cover as large a surface as possible, yet not be displaced by the action of these muscles. At the symphysis is the frenum labii inferioris, formed by the blending of a few fibers from each of the levator labii inferioris and the covering of mucous membrane. Sometimes another frenum is formed just distal to the lower cuspid eminence. This buccal frenum should, when existent, be provided for in the periphery of the base-plate.

Muscles of the Maxilla.—There are few muscles of the maxilla other than the buccinator that interfere with the retention of the artificial upper denture. The depressor alæ nasi and compressor naris have their origin in the incisive fossa and require attention because of their influence upon facial cosmetics. When the alveolar process is largely resorbed the attachments of these muscles are sometimes in close proximity to the alveolar crest. The tendency seems to be for the prosthetist to pad out or bolster up these muscles with the idea of restoring the expression. By studying the origin, insertion, and action of these muscles it will be seen that the desired result cannot be obtained. The endeavor should be not to exaggerate the deformity. The depressor

alæ nasi has two fasciculi, the one going to the wing and septum of the nose and the other forming the depressor of the upper lip. These few fibers, in conjunction with a like portion from the other depressor alæ nasi and a well-marked fold of mucous membrane, constitute the frenum labii superioris. When it is recognized that the function of this muscle is to draw in or depress the upper lip and the tip of the nose, and that the receding process carries the origin of this muscle farther back than normal, it will readily be seen that any crowding upward of this muscle tends to still further curl inward the upper lip and the tip of the nose. Therefore it is necessary that the base-plate shall be well cut away to permit free play of the frenum, and that the flange of the base-plate passing over the incisive fossa shall be well depressed. Otherwise there will be a pouched-out effect of the lip just under the nose. The buccal frenum over the upper first bicuspid must not be impinged upon by the base-plate.

The Soft Palate.—The soft palate (velum palati) is the curtain between the vault of the mouth and the pharynx, and is composed of six pairs of small muscles, each having one of their attachments upon the palate bones. In some cases these muscular attachments will extend farther forward than usual, and in such cases may interfere with the retention of an artificial denture if the base-plate is improperly adjusted to them. This same improper adaptation may not only cause loosening of the artificial denture, but also nausea. However, the base-plate, for best retention, must extend in every direction as far as the muscles will permit, because, other conditions being equal, the retention of artificial dentures is in direct ratio to the area covered.

The above paragraph has expressed the teaching of the profession until quite recently, but now it is known that the principle herein taught is only in part true, for *there are a large number of cases in which the best results are obtained by extending the palatal border of the artificial denture well upon the yieldable soft tissue.* This new thought will be discussed in the chapter on Retention.

PHYSICS OF THE MUSCLES OF MASTICATION AND TEMPOROMANDIBULAR JOINT.

Gray says (page 298, 20th edition): "The movements permitted in this articulation are extensive. Thus, the mandible may be depressed or elevated, or carried forward or backward; a slight amount of side-to-side movement is also permitted. It must be borne in mind that there are two distinct joints in this articulation—one between the condyle and the articular disk, and another between the disk and the mandibular fossa. When the mouth is slightly opened, as during ordinary conversation, the movement is confined to the lower of the two joints. On the other hand, when the mouth is opened more widely, both joints are concerned in the movement; in the lower joint the movement is of a hinge-like character, the condyle moves around a transverse axis on the disk, while in the upper joint the movement is of a gliding character, the disk together with the condyle, gliding forward on the articular tubercle, around an axis which passes through the mandibular foramina. These two movements take place simultaneously, the condyle and disk moving forward on the eminence, and at the same time the condyle revolves on the disk. In shutting the mouth the reverse action takes place; the disk glides back, carrying the condyle with it, and this at the same time moves back to its former position. When the mandible is carried horizontally forward, as in protruding the lower incisor teeth in front of the upper, the movement takes place principally in the upper joint, the disk and condyle gliding forward in the mandibular fossa and on the articular tubercle. The grinding or chewing movement is produced by one condyle, with its disk, gliding alternately forward and backward, while the other condyle moves simultaneously in the opposite direction; at the same time the condyle undergoes a vertical rotation on the disk. One condyle advances and rotates, the other condyle recedes and rotates, in alternate succession.

"The mandible is depressed by its own weight, assisted by the platysma, the digastricus, the mylohyoideus and the geniohyoideus. It is elevated by the masseter, pterygoideus

internus and the anterior part of the temporalis. It is drawn forward by the simultaneous action of the pterygoideus internus and externus, the superficial fibers of the masseter and the anterior fibers of the temporalis; and backward by the deep fibers of the masseter and the posterior fibers of the temporalis. The grinding movement is caused by the alternate action of the pterygoidei of either side."

This statement is concise and probably is the latest accepted description by anatomists of the composition and action of the temporomandibular joint. A study of the physics of the individual muscles, and of their combined action, will help to develop an understanding of the function of the masticatory apparatus.

The function of a muscle fiber is to draw its inserted end toward its origin in a straight line. Two or more muscles that are not parallel but acting simultaneously will produce a resultant action. The resultant action is influenced by the ratio of the power of the muscles involved as well as by the direction of their individual activities. It is by the result of the combined action of the muscles that their function is determined. Therefore, the parallelogram of forces will demonstrate the physics of mastication and the principle included.

The superficial portion of the masseter, and the internal pterygoid muscles act in conjunction with each other in a direct thrust, and in a vertical and forward direction, at approximately an angle of 25 degrees from the perpendicular. The posterior portion of the temporal muscle acts also in the direct closing thrust of the mandible; however, its line of force is upward, and about 45 degrees from the perpendicular backward. Illustrated by the solid arrows in Fig. 9. As the power of the combined action of the masseter and the internal pterygoid is two to three times as great as that of the temporal muscle, the parallel lines of the parallelogram representing the thrust of these muscles must be two to three times as long as the parallel lines representing the thrust of the temporal muscle; therefore, the diagonal line of an oblique parallelogram will represent the resultant of the action of these three muscles. As the resultant is at right angles to the

occlusal plane, it is evident that the whole force of these muscles is expended upon the bolus of food and not any portion of it upon the condyle. Therefore the condyle is not a fulcrum and the mandible is not a lever of the third class.

Fig. 9

This diagram is the true physical demonstration of the action of these muscles; however, a variation of the demonstration may be more easily comprehended. As force acts in a straight line, and a force acting upon a solid body acts upon every portion of that solid body in parallel lines; therefore the action of the temporal muscle attached to the coronoid process is just the same as if the attachment were

carried forward to the apices of the incisor teeth. By constructing the parallelogram below, and to this extended line, it may be easier to conceive of the resultant force being at right angles to the occlusal plane. (See lower parallelogram, Fig. 9.)

A further proof that the mandible is not a lever of the third class is found in the parallelogram of forces (see broken lines, Fig. 9) constructed upon the lines of force of the deep portion of the masseter which draws the mandible upward and backward; and the anterior portion of the temporal muscle which draws the mandible upward and forward. The resultant force of these minor portions is in the same direction as the resultant force of the major portions of these muscles; however, they act as a stabilizer, and make more positive the intent of the action of these muscles.

Another positive evidence that the mandible is not a lever of the third class is found in the action of the external pterygoid muscle. This muscle is inserted into the neck of the condyloid process of the mandible, and into the articular disk. The function of this muscle is to draw the mandible and articular disk forward and inward. This results in drawing the condyle and articular disk, with its lubricating sacks, on to the articular tubercle. Therefore, if the mandible is a lever of the third class, then the fulcrum consists of a lubricated inclined plane, a mechanical construction unthinkable of our conception of the Omnipotent Architect. Hence, if the articular tubercle does not function as a fulcrum, the mandible does not function as a lever of the third class.

Another very strong evidence that the mandible is not primarily a lever of the third class was presented by H. J. Prentiss, M.D., Professor of Anatomy at the University of Iowa, in a paper published in the *Dental Cosmos*, June, 1918. This is an exceedingly interesting article and can be read with profit by every member of the dental profession. The paper is based entirely upon laboratory investigations of various joints. He considers the histology of the knee-joint from early embryonic to adult life. He says: "We see, therefore, in the knee-joint a retrograde absorption of the meniscus (articular disk) which is necessary to a normal function of

the joint. The sequence of events just followed in this joint (knee) may be traced to the mandibular joint, only here it becomes pathological with the loss of the teeth."

This is positive evidence that the action of the mandible is not primarily a lever of the third class, and that when it does become such, as the sequence of the loss of the teeth, then it results in a greater or less destruction of the articular disk.

These four evidences show conclusively that nature did not design the mandible as a lever, but as the moving part of a mill.

Consider the masticatory apparatus of man as a mill. This can best be done by inverting the head, when the maxillæ become the nether millstone and the mandible the upper and movable millstone; the maxillary molars and bicuspids represent the convex surface, and the molars and bicuspids of the mandible represent the concave rotating or triturating surface; the rami are balancing arms supported by ball-and-socket joints, the movements of these joints are limited in scope by the ligaments; and the milling power is furnished by the muscles.

This arrangement would result in the loss of gravitation and require more power in separating the millstones for the insertion of the grist, and would place more pressure upon the articular disk causing the perforation of the articular disk to become a physiological process, which is not the intent of nature. Nature reversed this order and suspended the movable millstone, thus conserving energy, reducing friction and preserving tissue. This suggests the function of the ligaments and fasciæ (suspensors). This principle of suspension in mechanics is used in some of the greatest engineering schemes of man. For instance, the electric power plant at Niagara Falls, where the generating power consists of a column of water falling 185 feet and entering the turbine wheel from beneath, thereby reducing friction to a minimum and providing a maximum of energy.

The last of the assemblage of factors to be presented as proof that the mandible is not primarily a lever of the third class is the purpose and action of the ligaments. The purpose

of ligaments is to act in the capacity of a rope. They are flexible, but neither elastic nor contractile; they act to suspend and to restrict. The action of the temporomandibular ligament should be elucidated. The quotation from *Gray's Anatomy*, previously given, states: "In the upper joint the movement is of a gliding character, the disk, together with the condyle, gliding forward on to the articular tubercle, *around an axis which passes through the mandibular foramina.*" The location of this axis is an error, which is based upon the supposition that the stylomandibular ligament and the sphenomandibular ligament are the fixation forming this axis.

Such an action is an impossibility, for if this rope-like attachment existed the mandible could not be protruded. It is the temporomandibular (external oblique) ligament that performs the function of the axis of rotation of the upper joint. In opening the mouth the head of the condyle first rotates on an axis on the under surface of the articular disk, as stated by Gray, when the temporomandibular ligament is made taut, its insertion at the neck of the condyle becomes the axis of rotation, and the head of the condyle and articular disk travel forward on to the articular eminence. As this ligament passes from the zygomatic process of the temporal bone downward and backward to the neck of the condyle its pendulous nature permits protrusion of the mandible, whereas the fibers of the stylomandibular, sphenomandibular ligaments pass downward and forward and cannot act as the axis of rotation and permit protrusion. Therefore, as it permits protrusion it is not the axis of rotation.

The stylomandibular and sphenomandibular ligaments are long thickened bands of fascia colli (deep cervical fascia) and function as pendulous suspensors. Incidentally these ligaments, with the other temporomandibular ligaments, may aid the mandible in acting as a lever of the second class (as a nutcracker), just as certain conditions may arise so as to cause the mandible to act as a lever of the third class; but these are not the primary or normal functions. Therefore, the temporomandibular joint is a compensating joint, and designed to aid the various factors in the masticatory apparatus in conforming to requirements.

This evidence and reasoning should and does establish the soundness of the statement that the "mandible is not a lever of the third class."

The Teeth.—In the human family the teeth are the hard, flint-like, symmetrical formations placed within the mouth for the purpose of preparing the food for deglutition. They serve also as an aid in speech, but this is a secondary function, and an esthetic rather than an anatomical subject.

It is necessary to study the general characteristics of the natural teeth that we may have a comprehensive appreciation of the demands made upon artificial substitutes.

As the teeth of a skull are viewed in mass they are seen to be in two parabolic rows (Figs. 3 to 6). The upper row is fixed or stationary, while the lower one is attached by a hinge (mandible), which carries them into intimate relation with the upper. As these two rows of teeth are held firmly together there is seen to be a method in their form, grouping, and arrangement. Proceeding from the median line in either direction, in the upper jaw, the first two teeth present a straight edge, the next three a single point, and the last three two points each. It is seen also that the upper teeth overlap the lower, and that the mass of teeth viewed as a column has the general form of a truncated cone. The straight-edged teeth are for cutting the food, and are called incisors, central and lateral. The group of three, with one point each exposed when the upper and lower rows are in occlusion, will be found to differ in form when the rows are separated and they are viewed upon their ends (Figs. 10 and 11). It will be found that the anterior one only has but one point or cusp, and hence is called the cuspid. The remaining two teeth of this group have two points, one terminating the outer or buccal surface, and the other terminating the inner or lingual surface. These teeth are called first and second bicuspid (*bi*, two, and *cusp*, point; two-pointed, bicuspid). The remaining three teeth at the end of the parabolic row will be found, when viewed upon their ends, to have from three to five points, usually four; these teeth are called molars —first, second, and third molars. (Molar is from molaris, belonging to a mill, derived from mola, millstone; molo,

grind.) The teeth are, in order, named: central incisor, lateral incisor, cuspid, first bicuspid, second bicuspid, first molar, second molar, and third molar. The names of the teeth are preceded by adjectives denoting location, as right or left and upper or lower. Thus, to indicate a certain tooth, it should be described as right upper central incisor, left lower first molar; that is, first indicate the side of the body, second the jaw, and third the distinctive tooth.

There is another classification that, because of its origin, needs consideration. The Basle Anatomical Nomenclature (BNA) has the highest endorsement of anatomists and biologists. It is in correct Latin and is designed to do away with duplicate anatomical terms. To have one definite name for an anatomical object is most desirable; but for a body of general students to elect terms for the specialist student is apt to be quite unsatisfactory. The author of this book is of the opinion that the specialist student should not acquiesce until his claims have been carefully considered. When brevity and simplicity are the cardinal points of a scheme, it is certainly illogical to adopt the more cumbersome and less significant classification. This is the relation of the BNA tooth classification as compared with the tooth classification of the dental profession. The following is the BNA tooth classification with the English interpretation, as given by Dr. Barker, in brackets: Dentes incisivi (incisor teeth); dentes canini (canine teeth); dentes præmolares (premolar teeth [O. T., bicuspids]); dentes molares (molar teeth); dens serotinus (late tooth [O. T., wisdom tooth]).

There is no good reason for placing the third molar in a class by itself, and the term serotinus (late) is as obnoxious as the obsolete term, wisdom tooth. Premolar is no shorter than bicuspid, does not describe the tooth as well, and has the disadvantage of having been used by some writers to indicate the deciduous molars. Canine (dog) has no scientific significance. As both classifications will confront the student, he should know the writer's authority and reason for each. This book gives preference to the former rather than the latter classification.

Returning to our observation of the teeth in the skull

(Figs. 10 and 11) it is seen that the upper central incisor is wider than the upper lateral incisor, that the lower central incisor is slightly narrower than the lower lateral incisor, and that the upper incisors taken together are much wider

Fig. 10

Fig. 11

than the lower incisors. Dr. Black gives the average width (in millimeters) of the crowns of the teeth as follows:

	Central incisor	Lateral incisor	Cuspid	First bicuspid	Second bicuspid	First molar	Second molar	Third molar
Upper	9	6.4	7.6	7.2	6.8	10.7	9.2	8.6
Lower	5.4	5.9	6.9	6.9	7.1	11.2	10.7	10.7

This formation permits all of the lower central incisor and half of the lower lateral incisor to occlude with the upper central incisor (Figs. 3 to 6), the lower lateral incisor to occlude with the upper central and lateral incisors, and the lower cuspid to occlude with the upper lateral incisor and cuspid. This arrangement continues throughout the line of teeth. In other words, each tooth, excepting the lower central incisor and upper third molar, occludes with two teeth. This arrangement necessarily places each tooth of the lower row, excepting the central incisor, half of its width (approximately) in advance of its fellow of the upper row. The fact just stated is fundamental, and should be fixed in the student's mind as a landmark. For emphasis, the proposition is restated. *Excepting the central incisor, each lower tooth is approximately half its width in advance of its fellow in the upper parabolic curve.* In arranging the teeth of a complete artificial denture this interlocking of the teeth should always be produced. The teeth should not be arranged end to end, but interlocked one against two. Farther on the mechanical reasons for this interlocking will be developed.

Parabolic Curve.—A parabola is a section of a cone cut parallel with one of its sides. This will form a figure with a half-circle at one end, a straight line at the other, and the ends of the half-circle and straight line joined by diverging straight lines. If a skull with typically arranged teeth is held in the hand so as to secure a direct view of the morsal ends of the upper teeth, it will be seen that the teeth describe nearly a perfect parabola (Fig. 10). Dr. Bonwill demonstrated that the segment of the circle described by the six anterior teeth has a radius equal to a line drawn from the mesial incisal angle of the central incisor to the distal incisal angle of the cuspid. The student should appreciate that to study any subject pertaining to nature it is necessary to have an ideal—a type as a standard for comparison. It is an axiom that Nature never exactly reproduces herself, therefore science groups the easily recognized modifications of the type into classes.

In studying a large number of human mouths it will be

observed that in many cases the segment of the circle will have somewhat of a square form, in others it will be somewhat V-shaped (with apex to the front), and in others a flattened round. Three types will be further considered in the chapter on Esthetics. When the teeth are all *in situ* the radius of the circle may be easily obtained with a pair of dividers, but when the maxilla is edentulous it is another proposition. The next observation is to determine how to secure this radius in an edentulous subject. Upon the skull may be observed an elevated ridge, cuspid (canine) eminence, over the root of the cuspid tooth. This eminence terminates just external to the outer corner of the anterior nares. The student may place his finger upon his own lip over the cuspid eminence and it may easily be felt. By moving the finger upward it will be found that this crest terminates within the triangle formed by the upper border of the lip, the wing of the nose, and the linea nasolabialis. This point indicates the termination of the influence of the cuspid root. Thus, a point of the dividers placed at the center of the base of this triangle and the other point of the instrument placed in the median line just below the crest of the anterior nasal spine will indicate the length of space to be occupied by the central, lateral, and mesial half of the cuspid tooth. With the dividers so set, and teeth selected to conform with the space indicated, the radius of the required circle can be obtained by extending the dividers to cover the distal angle of the cuspid. In practice it is unnecessary to use the instrument for this purpose, for the wax occlusion model should be so constructed that the cuspid eminence is established by the mouth. The student should remember that this cuspid eminence entirely disappears with the resorption of the alveolar process; so that the labio-naso-buccal triangle is his one guide in determining the width of the anterior teeth; also the radius of the dental circle. (Some operators consider that the angle of the mouth indicates the distance to which the anterior teeth should extend. This is, however, a very unreliable guide by which to determine the width of the anterior teeth, because of its instability and the seeming lack of uniform conformity between the slit of the mouth

and the other features of the face.) The prosthetist should establish a mental vision of the segment of the circle described by the anterior teeth and use it as an outline by which to arrange the artificial teeth in each individual case. He should also keep in mind the parallelogram described by the suture of the maxilla and the cuspid eminence. By continuing the segment of the dental circle it is seen that the line not only passes along the incisal edge of the incisors and cusp of the cuspid, but also through the buccal cusp of the first bicuspid; and then obliquely across the sulcus of the second bicuspid, and across the mesiolingual cusp of the first molar (Fig. 10). In viewing the morsal surface of the upper denture, it will be seen that if a straight line is drawn from the summit of the cusp of the cuspid to the summit of the distobuccal cusp of the second molar, the line will fall across all the intervening buccal cusps. The third molar is usually deflected either lingually or buccally from the buccal cusp line. This buccal cusp line always diverges, to a greater or less extent, from the median line of the skull. A view should now be taken of the side elevation of the skull, and it will be seen that the teeth plane is identical with the diverging cusp line. Again, attention is called to the short compensating plane formed only by the elevation of the second and third molars. (Other writers describe a longer compensating plane which includes the elevation of the distal cusp of the first molar, and often of the entire tooth.) Dr. Bonwill and his successors have erred in considering the curve of Spee and the teeth plane equivalent one to the other.

Truncated Cone.—In viewing the occluded teeth, as a mass, it will be seen that they present the form of a truncated cone. This is necessarily so because the crest of the alveolar process of the mandible describes a larger circle than the crest of the alveolar process of the maxilla. This arrangement favors concentrating the bolus of food, by giving a lateral inclination to the grinding teeth, the lowers being inclined inward (Fig. 12[1]) and the uppers being inclined outward. Usually

[1] Fig. 12 from photograph of specimen in the Wistar Institute of Anatomy.

the incisors, both upper and lower, incline somewhat outward. In some cases the lower incisors incline inward, and in a few instances the upper incisors incline inward, giving a snake-like appearance to the mouth. It is quite probable that this unsightly appearance is the result of the unfortunate loss of the permanent first molars in youth. Too often the dentist gives this unnatural inclination to artificial dentures. It is rarely, if ever, justifiable.

FIG. 12

There is usually an inclination of all the teeth toward the median line of the skull. This is partly due to the conformation of the individual tooth and partly to the tilting of the teeth bodily in that direction. As age and especially as certain diseased conditions progress this mesial inclination prevails.

Function of the Teeth.—In mastication there are three functions of the teeth, namely—prehensile, tactile and comminution. Prehension is a very primitive function and in the primate man is nearly extinct. The tactile sense in man is quite specialized, it serves to guide the teeth into proper relation with each other, and to protect the teeth against excessive stress. The sense of touch is transmitted through the teeth to the nerve filaments of the peridental membrane. The touch sense seems to be most highly developed in the cuspid teeth. When the teeth are lost this touch sense seems

to be lost and the individual seems to revert to the primitive prehensile function. However, when the lost dental organs are replaced with artificial dentures the touch sense is soon restored by educating the mucous membrane covering the alveolar process which is in contact with the restoration.

It is very evident that the tactile or touch sense is not in the temporomandibular joint. The function of comminution is as an aid to insalivation of the food.

Eruption of the Teeth.—Nature seems to have an admirably adapted plan for the erupting of the permanent teeth. This function begins with the lower first molar, upon each side of the mandible, at about six and one-half years of age. This tooth erupts in the angle formed by the body and ramus of the mandible. It is a wise provision of Nature, as it is the most fixed portion of either parabolic curve, and becomes the guide to the eruption and development of the entire dental armament. It is supported by the coronoid column of the ramus and causes the forward development of the alveolar process. As this tooth is in a fixed and fortified position, it directs and sustains the upper first molar through their interlocking cusps. These two teeth upon each side of the mouth being established, the other teeth must assume their normal position and usefulness unless interfered with by abnormal conditions. The dental student cannot too early become imbued with the importance and necessity of preserving throughout life the first permanent molars. The lower teeth are all erupted in advance of their correspondents in the upper dental curve (arch). For this reason some dentists have argued that the lower artificial denture should be set up first, and the upper arranged to the lower. This argument is not tenable, because the reason for the order in which nature places the teeth is entirely different from those confronting the dentist. Nature's foundation principle is to develop the jaws, while the dentist is required to secure mechanical leverage for retention of the artificial substitute. As the maxilla acts as a fulcrum, the upper teeth must be properly and securely placed. The second reason is cosmetic. The upper anterior teeth have much the larger part in establishing the contour and expression, while the

arrangement of the lower teeth is little more than mechanical.

The Alveolar Processes.—The alveolar processes are the portions both of the maxilla and mandible that support the teeth. They develop with the teeth and disappear with their loss. The alveolar processes are removed by resorption. The process of removal is quite active for six months, after which it is much slower for six to twelve months longer, when it is spoken of as a settled or a permanent process upon which an artificial denture may be placed which is designed to be worn for a few years. It is the changing relation of the processes of the two jaws that makes the wearing of artificial dentures so difficult for some people. If measurements were to be made of the crest of the alveolar ridges of the

FIG. 13

maxilla and mandible soon after the removal of the teeth, it would be found that the radius of the summit curve would be greater in the mandible than in the maxilla. This is evident because of the truncated cone formation of the dental armament. As the long axis of a cross-section of the body of the mandible is divergent from above downward, it is apparent that the radius of its summit curve must increase with its summit recession. While the radius of the summit curve of the mandible is constantly increasing with resorption, the radius of the summit curve of the maxilla is constantly decreasing, therefore increasing the difficulties inherent in wearing artificial dentures. As the palatal processes are the least changeable of any portion of the maxilla, the schematic drawing (Fig. 13) will explain why

the crest of the maxillary process recedes so rapidly inward as well as upward. The two views of the edentulous skull show the result of resorption (Figs. 14 and 15[1]). It is cus-

Fig. 14

Fig. 15

[1] Figs. 14 and 15 from photographs of a specimen in the collection of Dr. M. H. Cryer.

tomary to say that where resorption has continued for twelve to eighteen months they are in a permanent condition. This is only relatively so, for the processes may slowly continue to resorb for many years, not only until the surfaces occupied by the alveolar processes are perfectly flat, but until there is an extensive concavity. This is especially true of the mandible. The author, in his practice, has constructed two lower dentures in which a portion of mandibular surface of the base-plate of the artificial denture was convex to the extent of nearly half a circle. This condition does not imply added difficulties in the retention of the denture, but it does imply decreased substance in the mandible and increased danger of fracture.

THE USE OF THE MOUTH.

Mastication.—As the first essential for a man is his life, so the first and most important use of the mouth is to prepare the materials of sustenance for deglutition and assimilation. The teeth are most important organs in this operation. The incisors cut off morsels of food of sufficient size for comminuting between the grinding teeth. The bicuspids are designed especially to lacerate fibrous food, while the molars are designed to pulverize and triturate the food with the fluids of the mouth. It is the importance of these organs in preparing the food for its onward movement that creates the dental profession for their preservation, and restoration when lost. The physiology of mastication is beyond the scope of this book, but its importance is so great that the dental student should familiarize himself with the subject to a greater extent, if possible, than the medical student. In fact, the dental student should consider that he is intrusted with the comfort and preservation of the most vital organs of the human economy. It is a lamentable fact that the profession has not yet arrived at that stage of proficiency by which the organs of mastication, in all cases, can be preserved for use and comfort; therefore the dental prosthetist is necessary to provide a substitute for the lost dental organs. The dentist should appreciate that this office is

very important and not one to be thoughtlessly turned over to incompetent hands. The student of prosthetics should delve thoroughly and earnestly into the art, science, and esthetics of restoration that he may properly serve those needing his services.

Speech.—Articulate speech is the means by which man communicates his thoughts. The sounds forming speech are produced by air passing over the vocal cords aided by the resonant chambers of the chest and head. The mouth with the tongue is the most important aid to the vocal cords. The teeth are important factors of the mouth in vocalization, as they give support and shape to the side walls (cheeks) and tongue. When the teeth are lost, certain muscles must be developed and a greater effort is required on the part of the speaker. With the loss of the teeth there is a permanent loss of certain qualities of resonance and clearness of enunciation that cannot be reacquired by developing the soft tissues. However, by the aid of artificial dentures the original conditions can be so nearly restored that a defect in speech can only be detected by the trained ear. Indeed, in some cases of natural defects and deficiencies of the mouth great improvement of the speech may be made possible by properly constructed artificial dentures and appliances. Artificial dentures may be an impediment to speech, by the base-plate not conforming to the parts upon which they are supposed to rest, thus acting as an edge to split the expelled air of vocalization; or the artificial appliance may be so cumbersome that it fills space required by other factors of enunciation. However, all deficiencies of speech observed in people wearing artificial dentures are not due to improperly constructed substitutes. The personal equation is an important factor. Thus, lisping and whistling are often entirely unnecessary, being faulty conformation of the tongue. Where the prosthetist has satisfied himself that the base-plate is properly fitted and retained, and that there is no unnecessary incumbrance to the movement of the tongue, he should explain and perhaps demonstrate to the patient that the defect in speech is due to the faulty use of the tongue. The proper contour and conformation of

artificial dentures will be considered with the technic of construction, and on pages 530 to 537. The object sought at this time is to establish the fact that artificial dentures are an important factor in both restoring and impeding speech.

RESULTS OF LOSING THE TEETH.

Importance.—The importance of the teeth cannot be questioned. Their eruption and retention develop the lower third of the face, and have much to do with cosmetics. They are useful in the formation of speech, and, above all, they are necessary in preparing the intake of food.

Results of Loss.—The loss of one or more teeth in youth will prevent the full development of the face and seriously interfere with the usefulness of the remaining ones. The loss of one or more teeth in adult life weakens the mesiodistal support of the dental armament and exposes a portion of the gum to injury during mastication. The loss of the entire dentures makes impossible the mastication of food. There are a few exceptions to this statement, as there are cases in which the opposing jaws may be brought in contact, and, by use, the gum tissue becomes so toughened that the food can be mashed and insalivated. It is a safe statement to make that the loss of all the natural teeth adds ten to fifteen years to the apparent age of the patient, and it quite likely cuts off as many years of his natural life. It is the province of the operative dentist to prevent these calamities, and the duty of the prosthetist to supply substitutes for the losses sustained by accident, ignorance, or necessity.

The statement is often made that a patient can only use about one-fourth as much force with artificial dentures resting upon soft tissues as could be used with healthful natural teeth. This is probably true, but it should not be assumed that artificial dentures are only one-fourth as effectual as natural ones; because in no case does a patient anywhere near use the maximum of his power in preparing and masticating the food. However, there can be no question but that more time is required to properly insalivate the food with artificial substitutes than with healthful natural ones;

and there is undoubtedly more temptation to bolt the food. The loss of the natural teeth should be considered a calamity, but in such a misfortune one should be grateful for the services of the prosthetist.

A word as to the time of removing the natural teeth and replacing them with artificial substitutes. It should be established as a fact that the removal of the natural teeth at any time is more or less a shock and a strain upon the nervous system, and especially so if the patient is in an exhausted or a debilitated condition. Under such conditions no more teeth should be removed than is necessary to give relief from pain and remove danger of septic infection. The dentist should be very cautious about attempting to construct and insert artificial dentures while he patient is much below par in physical vigor. It is not an uncommon incident or the dentist to be told that "father or mother must have some new teeth, as he or she is failing rapidly." In these cases the dentist should satisfy himself that there is a lack of adaptation of the artificial dentures being worn, and that the unsatisfactory condition is not due to a lack of tone of the tissue, in which latter extremity he cannot successfully insert new dentures.

EXAMINATION OF THE MOUTH.

Seating and Protecting the Patient.—The patient should be seated in a dentist's operating chair, facing a good light. The chair should be adjusted to the comfort of the patient, and tilted slightly backward. A napkin should be fastened about the neck of the patient as a protection to the clothing. If, after examination, an operation is to be performed that may soil the patient's clothing, a further suitable covering for protection should be provided. The mouth mirror and all instruments used about the mouth should be scrupulously clean.

Cleansing the Hands.—Special emphasis is placed upon the cleansing of the hands. Surgical cleansing is not necessary, but mechanical cleansing is imperative. It is not sufficient that the hands have been thoroughly cleansed just before the

patient enters the office, but the patient should be conscious that the hands have been laved either just before or just after he or she is seated in the operating chair. The impression produced is most beneficial. The attention given the hands will cause the patient to unconsciously, perhaps, conclude that the instruments are not only apparently clean, but are clean. The dentist should establish a regular course of procedure. His manner should be positive but gentle. These attentions and methods will have much to do with securing the confidence of the patient.

Method of Examination.—A mouth mirror, an examining point, a pair of cotton tweezers, possibly a blunt probe, absorbent cotton, a supply of aseptic mouth napkins, and a water syringe should be accessible. A compressed-air spray is often convenient, but is not a necessity in examinations, for the water syringe will take its place. The operator should stand at the right and slightly back of the patient. This position will give a good view of the mouth, and the person of the operator will not obstruct the light. This position is advantageous for manipulation.

The first glance should observe any inflammatory (sore) conditions of the lips, and then of the interior of the mouth, when, if such exists, the operator should endeavor to cause the patient as little discomfort as possible, yet be thorough. Should there be any suspicion of an infectious condition, the operator should use every precaution to protect himself, and after the patient is dismissed every instrument used about the patient's mouth should be sterilized. (Sterilization is taught by another chair; however, when not contraindicated, keeping the instruments submerged for thirty minutes in boiling water will be very effectual.)

With the mouth mirror in the right hand and the assistance of the fingers of his left hand, every portion of the mouth cavern should be brought, in turn, under inspection and investigation. Should the operator observe that there is resistance on the part of the patient, such as moving the head or contracting the lips, he should instantly cast about for an explanation. He should satisfy himself that there is no evidence of filth about his hands or instruments, or

that he is not unconsciously pulling the patient's hair, pressing a cuff-button into the ear, handling the mouth in an awkward manner, or causing unnecessary pain. These possibilities of discomfort should in an instant be detected by thought and a glance. Having satisfied himself that he is not at fault, but that the patient is fearful or over-sensitive, he should endeavor to overcome these conditions by his gentle manner and kindly speech. Often the simple request to relax the mouth, expressed in a gentlemanly manner, will be all that is necessary. At other times an assurance that the work in hand does not necessitate pain, an explanation of what is desired, or of the condition found, will place the patient at ease through the confidence gained.

What to Look For.—The things to be observed in the mouth are: Remaining teeth and roots, shape of arches and vault, size of maxillary and mandibular surfaces, extent and condition of the alveolar processes, muscular attachments and glandular tissue, mucous and submucous tissues, and fluids of the mouth. We will consider each of these in the order named.

Teeth and Roots.—A good rule for the dentist to establish is: The difficulties of inserting, and often in using, artificial teeth are in the ratio to the number required. While there are many exceptions to this rule, it is a safe one when considering the advisability of extracting teeth. Another rule is: A base-plate should not be placed over a root unless the root is used as a means for support of the artificial denture. Unused roots are a source of irritation, and usually add to the instability of the artificial denture. However, if the root can be placed in a healthy condition and crowned, or used as an attachment for the artificial appliance, it may be very valuable. The advisability of retaining the cuspid roots as an aid to expression is very questionable, unless they are used for the retention of the artificial denture. In practice, when preparing the mouth for artificial dentures, the operator must often determine whether he will or will not retain one or more sound and firm teeth. In no case should such teeth be removed until their usefulness as a means of retaining the artificial ones has been carefully considered.

Sometimes a single tooth is of great value in supporting an artificial denture; especially is this true in the mandible. A single tooth in the maxilla may be of great value when the conditions are unfavorable for the usual methods of retaining full dentures. Two teeth in either the maxilla or mandible, if properly located, may furnish the best possible means of securing the artificial denture. However, a tooth or two may be so located that their retention will be a positive detriment to the wearing of artificial dentures.

It often happens that the patient places much value upon the few remaining teeth, either for their use or cosmetics. If there are two teeth, one in each jaw, opposing each other, it is always doubtful wisdom to remove such; though they may, as they doubtless will, interfere with the retention of artificial dentures. In advising the patient, the dentist must take into consideration that the personal equation is an important factor; that the patient may be one who will never make a success of wearing artificial teeth. However, one factor that the patient should be apprised of regarding the retention of one or more incisors only is that if any movement of the artificial teeth occurs, it is made conspicuous by reason of the stationary condition of the remaining ones. The chapter on Retention of Artificial Dentures will consider the relative value of individual teeth.

Arches and Vaults.—The student should have a clear understanding of these terms. In common parlance an arch is an upright structure spanning an opening, but this does not apply to the dental arches. The dental arch has reference to the parabolic curve only of the teeth. It is often erroneously used to designate the curve of the roof of the mouth. Such use either shows ignorance or carelessness in the use of accepted dental terms. Vault is the term used to designate the roof of the mouth, the more or less curved span over the tongue. The dental arches are the curved lines described by the teeth of both the maxilla and mandible, while the vault is the curved line extending from side to side of the mouth, over the tongue.

The shape of the arches and vault will be similar in any given case. Thus, if the upper dental arch is V-shaped, the

vault will tend toward the same conformation. This is easily explainable. If in infancy and childhood some influencc is brought to bear upon the outer surfaces of the biscupids and molars (that is, the diverging straght lines of the parabolic curve), so as to compress them, it will also force the suture of the palatal processes of the maxillæ upward, giving the V-shape to the vault. Any continuous pressure upon the plastic osseous structure of youth will have its beneficial or detrimental effect. Thus, the shape of the dental arches and vault are similar unless they are acted upon by two or more opposing forces. While the shape of the arches and vault are supposed to harmonize with the "temperament" of the individual, they may be indicative only of abnormalities. The curve of the edentulous alveolar processes and the vault will indicate the curve of the teeth produced through nature, but that is no assurance that the natural teeth were in harmony with the rest of the physical organization. Consequently the curves of the alveolar processes and vault are of much interest, both directly and indirectly, to the prosthetist. The work being done by the orthodontists in bringing the teeth of youth into occlusion is of importance throughout life. It not only helps to preserve the teeth, at least to make them useful while they are retained, but it puts the mouth in the best possible shape for the retention of complete artificial dentures when such may be required. Some persons may foolishly have sound natural teeth removed because of their unsightly irregularity, and with the intent of having "beautiful" artificial ones inserted. If possible, before the teeth are extracted, the patient should be informed that the conditions of the mouth accompanying the mal-aligned teeth may add to the difficulties of using artificial dentures.

The maxillary suture or raphé requires special attention. This is part of the median line noticed in many portions of the body. Usually it is little more than a slight ridge or fold of mucosa; however, it may develop to the extent of an obstructive osseous tumor the size of a man's thumb. The author's belief (based on experience only) is that these osseous enlargements of the raphé are much more common

in the mouths of females than of males. If possible, the palatal border of the base-plate should pass about and not over these excessive enlargements; at least the pressure must be relieved the entire length of the base-plate; that is, even the posterior edge must be relieved. A vacuum chamber over any portion of this tumorous surface is more than useless. It only tends to concentrate the pressure upon the remaining portion of the tumor covered. Dr. L. P. Haskell states that 95 per cent. of all cases requiring artificial dentures need the pressure of the base-plate relieved over this portion of the vault.

Size of the Maxillary and Mandibular Surfaces.—The size of these surfaces is not always in harmony with the size of the individual. Sometimes a very large maxilla is associated with a small physical organization and mouth orifice; at other times the reverse occurs, and occasionally one is large and the other small. These varying conditions will influence the construction and wearing of artificial dentures. These conditions should be well noted in examining the mouth. The size of the maxilla and mandible is an important factor in retaining artificial dentures; other conditions (shape, soft tissues, tone, and fluids of the mouth) being equal, the amount of retention will be in the ratio to the flat surface (base-plane) covered. In estimating the amount of retention surface that may be of value in retaining a base-plate, only that portion through which direct pressure is brought to bear upon the maxilla or mandible should be considered. In those cases where the maxillary alveolus flares outward the crest of the alveolus should define the border of the base-plane. The buccal surface of this class of alveolar process will only serve to prevent lateral movement of the base-plate covering it, which, aided by the soft tissues, will exclude the air, and thus be of value in retention. The diagrams (Fig. 16) representing cross-sections of maxillæ will make clear this idea. The arrow points indicate the distance to which direct pressure may be applied, and the dotted lines indicate the relative base-planes. As the base-plates rest upon the soft tissue, it is obvious that pressure brought to bear upon it in the proximity of one arrow

only will be concentrated, and tend not only to dislodge the base-plate, but to bruise the supporting soft tissue; while pressure applied at any point approaching the median line will be more diffused over the base-plate, and consequently present greater resistance and better retention. This demonstration shows that the common statement that a flat vault is unfavorable for retaining artificial dentures is not well founded. The poor retention often observed in such cases is due to other causes and often to faulty technic only.

Alveolar Processes.—An earlier section of this chapter treats of the applied anatomy of the alveolar processes; this section will treat of them as supports for artificial dentures.

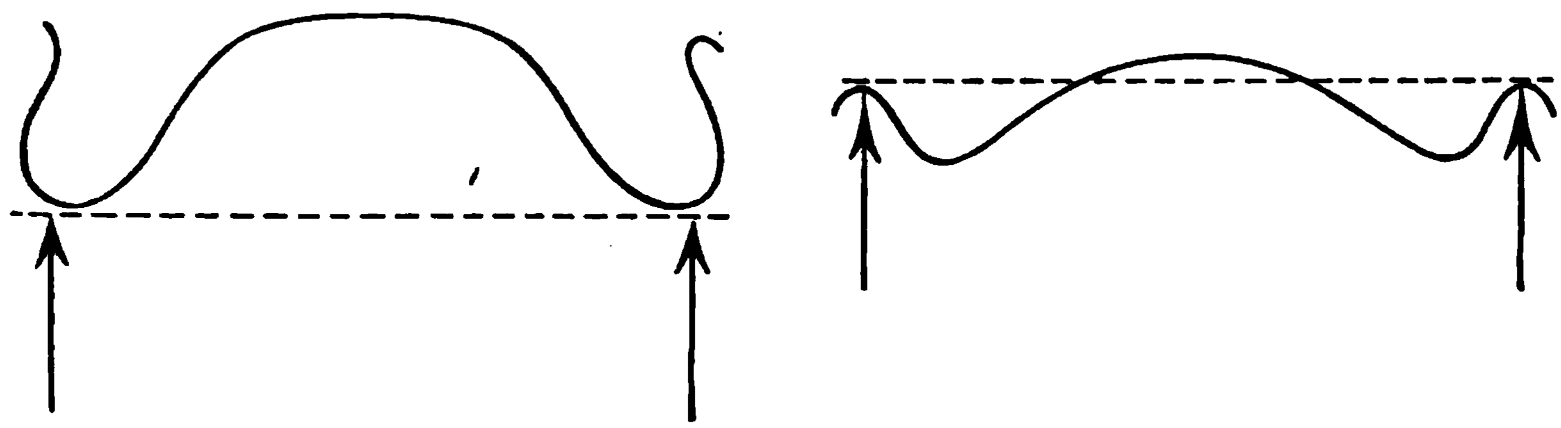


Fig. 16

When a number of teeth have been recently extracted, in common parlance the gums are spoken of as fresh gums, and when resorption has taken place they are called permanent gums. In a few days (seven to twenty-one) after the teeth have been extracted the gums will have closed over the alveoli, but the gums are not in a condition to withstand much pressure, yet they are in shape for temporary artificial dentures. No matter of what material the base-plate is constructed, when it has been constructed for fresh gums, the artificial denture should be considered as temporary. As the alveolar process recedes it ceases to properly support the artificial denture. The denture may become very insecure, and often irritates the tissues severely. During this process of resorption the base-plate may require refitting once or twice; however, when the artificial denture has been worn from twelve to eighteen months a new one should be

constructed. This is necessary to secure proper adaptation of the base-plate and for restoring the contour of the soft tissues.

As the soft tissues (after extraction) close over the alveoli a very irregular surface may present, from portions of the process having been sprung out of position, or possibly fractured to the extent of separation. In such mishaps the loose pieces should be removed at the time of extracting the teeth, or as soon thereafter as discovered; because the detached portion will not be resorbed by the physiological process, but assumes a pathological import. So long as the displaced portion of process is vitally connected with the bone structure, the physiological action will dispose of it. Meanwhile the pressure of a base-plate may be a source of much irritation, and will necessitate cutting away sufficient of the base-plate for relief. However, much of this discomfort for the patient and annoyance for the prosthetist can be avoided by treatment properly administered by the exodontist. The extraction of the teeth should not be considered the end of the responsibility of the extractor. Modern surgery requires that mutilated tissue shall be consistently dressed. Obviously much improvement can be made, over the negligence of past times.

Alveolectomy is a modern operation and it will require time to determine the extent to which it should be practised. Nevertheless it is a progressive step in oral restorations and will eventually be appraised at its true worth.

A well-retained artificial denture must have its greatest bearing as near the periphery of its inclosed base-plane as possible.

When the process of resorption is practically complete, several conditions may be present that should be observed. The process may be very prominent, so that the lip is full enough, and the absence of the teeth not noticeable when the patient is not speaking. In such a case, when laughing, the edentulous subject may show from a line to a quarter of an inch or more of the natural gum. Cases of this kind need no artificial gum to restore sunken lip and cheeks. Indeed, they probably present, when not speaking, a much

improved appearance from that possessed with the natural teeth. The artificial denture should be constructed without a gum portion as far back as the individual case shall require. This may require no artificial gum over the two central incisors, the four incisors, the incisors and cuspids, or, in extreme cases, no gum portion may be tolerated anterior to the first molars. The artificial teeth in these cases must be ground to set closely against the gum, indeed, press into and apparently grow from the gum. They may be placed with their labial surfaces in line with the crest of the process. or they may be carried outward and lap well over the process. The diagrammatic sketch (Fig. 17) illustrates these conditions.

FIG. 17

The vast majority of cases may be classed as regular, and present no complications.

The resorption may continue until the process is almost extinct, when it is classed as flat. The methods of handling these cases will be discussed in technic methods, especially the technic of impressions.

The process when receded may be broad or narrow. The broad alveolar ridge is ordinary, and the thin (knife-edged) ridge is only too common. They are a constant source of annoyance. In time the thin alveolar process disappears, leaving a pendulous, flabby gum. The base-plate should not be permitted to rest upon the sharp edge.

Sharp ridges may appear upon any portion of the process, especially upon the lingual aspect of the mandible. They will not tolerate the pressure of a close-fitting base-plate.

Nodules from the size of a millet seed to a lima bean, or larger, may appear on any portion of the maxilla or mandible. If they are to be covered with a base-plate the pressure must be removed from their entire extent. This can be done with one or more layers of No. 60 tinfoil.

Firm or pendulous: The firm gum consisting of an even layer of soft tissue is the desirable condition, but the pendulous and spongy gums indicate complications, and the extent of such complications must be ascertained.

Muscular Attachments and Glandular Tissues.—These may be observed and their obstructiveness may be judged by distending the cheeks and lips, and having the patient raise the tongue to the roof of the mouth. The sublingual and especially the submaxillary glands may interfere with obtaining a perfect impression of this portion of the mandible. The submaxillary gland may entirely cover the bicuspid and first molar portion of the mandible. The impression must be obtained of the surface upon which the gland rests and not of the gland. The method of doing this will be considered in the chapter on Impressions. The muscles and frenæ attached to the maxilla and mandible have already been considered, but on examining the mouth the location of their attachments and any obstruction they may present should be carefully observed.

Mucous and Submucous Tissues.—The mucous membrane covers the entire surface of the mouth. It is underlaid with more or less submucous tissue. The condition of these tissues is an important factor in retaining artificial dentures, and requires observation. While all the preceding organs and tissues which we have mentioned for investigation in examining the mouth are inspected by vision, and in a few instances by touch (either finger or instrument), the tissues (mucous and submucous) under consideration can be determined only by the sense of touch. It will be found that in some mouths the mucous membrane is very firm and tense over the whole surface upon which artificial dentures may be

worn; in others, that this membrane is largely underlaid with submucous tissue of more or less thickness. It is this class of cases that afford the greatest retention provided other conditions are favorable, and the submucous tissue is not excessive. A third class consists of those cases in which a portion of the surface is covered with tense mucous membrane and other portions are underlaid with submucous tissue. These three classes play an important role in the method of taking impressions and the method of securing the retention of the base-plate. They should be carefully examined.

Fluids.—The fluids of the mouth consist of a mixture of the saliva and mucous secretion. They may be in moderate amount, or they may be excessive; they may be thin, or thick and ropy. The thin, watery fluid and in moderate amount is the most favorable for good retention of artificial dentures. When the fluid of the mouth is excessive and strings from the mouth as an impression tray or an artificial denture is removed, it may be considered as an unfavorable factor. The thick secretion prevents that close adaptation necessary for the strongest retention.

Recapitulation.—Having a definite knowledge of what conditions may be found in the mouth, the examination is simple and expeditious. Ordinarily no record is made of the examination; however, much valuable information could in time be acquired if blanks were used for systematic work. When the prosthetist examines the mouth he desires to know the conditions presenting, so that he may determine at once whether it is an ordinary or a complicated case. The patient being comfortably seated, and facing good light, the operator makes a momentary visual and digital examination. By this preliminary examination he determines whether there is anything out of the ordinary that may complicate the work; if so, it must be given careful consideration. If he sees no complications, such as inflammatory conditions (sores), undesirable teeth or roots, ill-shaped arches or vault, disproportion between the maxilla and mandible, unfavorable muscle or frenæ attachments or gland complication, and no mucous and submucous tissue or fluid complications, he diagnos-

ticates the case as ordinary or simple, with success contingent only upon his technic and the personal equation of the patient. The prosthetist then determines the kind of restoration indicated, whether a bridge or an artificial denture, and the variety of either desirable or permissible. If there are complicating conditions present, he determines whether they are corrective or not, and, if not, how best to circumvent the difficulty. Having a clear conception of the requirements of the case, the prosthetist consults with the patient, as the involved expense may be prohibitive. An artificial denture supported upon a base-plate having been determined upon, the next step will be to take a suitable impression.

CHAPTER II.

IMPRESSIONS.

Definition.—An impression is a *negative* likeness of an object or part taken in a plastic material, form which a cast or *positive* likeness may be produced.

Scheme.—When the prosthetist determines to construct a base-plate artificial denture, he at once decides upon its general form and extent of surface to be covered with the base-plate. He also forms a tentative plan for retaining the artificial denture. This plan for retention may be altered or abandoned, as a result of a future critical study of the case; nevertheless, a definite scheme must be in mind before taking the impression, because an impression suitable for the contemplated appliance should be obtained. An impression that is most desirable for orthodontia may be entirely inadequate for prosthesis; and certainly an impression that is desired by either the orthodontist or the prosthetist may be distorted for the other. This statement is made to impress the student with the fact that an impression is not necessarily an *exact* negative likeness of a part, but it must be perfect in its suitableness for the work in hand. The soft tissue is the factor that creates the variableness in impressions. Rarely is an impression perfect for its intended use unless the soft tissues are, to a greater or lesser extent, distorted; nevertheless, this distortion must be suitable for its intended purpose. The methods herein detailed are for base-plate work. However, there is much in common in impression taking for all specialists. The extent of the impression should be governed by the kind of an artificial denture required, whether a partial or full, a saddle or adhesion base-plate. The impression should extend a little farther in every direction than the contemplated base-plate; but any

excessive extension causes unnecessary discomfort to the patient, and indicates indifference or thoughtlessness on the part of the prosthetist. Therefore a definite scheme or plan of procedure should be devised for the case in hand, and good workmanship requires that every step shall be neatly and accurately performed. This is a fundamental principle of mechanics, and, as a profession is superior to a trade, the prosthetist should show superior manipulation. Another thought for the young student of dentistry is this: There is no legerdemain associated with prosthesis, the profession being only an expression of cause and effect; therefore it behooves one to cultivate thoughtfulness and thoroughness in manipulation.

New Scheme.[1]—Modern ideas of impression taking are undergoing a radical change, or rather, there is a radical change in the appreciation of some old ideas. The new appreciation is that: *With full dentures—that as large an area as possible must be covered, that the periphery of the denture must extend upon yieldable tissue sufficient to form a valve-like*

[1] Great credit should be given the late Dr. J. W. Greene and Mr. Samuel G. Supplee for their improvements in materials and technic, also for the strenuous work they have done in teaching their improved methods to the profession. The underlying principles are not new. However, these men have devised an improved technic by which they used modelling compound in such a way as to emphasize the illy understood fundamental principles of retention. These men are entitled to much credit for the stupendous work they have done in arousing the profession to the possibilities of retention for full dentures. Nevertheless it is regrettable that they did not comprehend and with their splendid energy teach the underlying principles of retention and impression taking, in place of devoting their efforts to the technic of a material. Unfortunately the material with which they have labored, although it has much value as an aid to the prosthetist, is the most difficult to manipulate, and is also deceptive in the results obtained. It is the desire of the writer of this book to present the physics and technic of both retention and impression taking, in such a manner, that the reader may have a comprehensive and discriminating understanding of the relative value of the various materials and methods.

Again, the writer of this book wishes to emphatically express and acknowledge his obligation to these men as his teachers; but he feels it a duty to correct gross errors in their teachings. His contention is for truth, but he is not in any way opposing men.

Bryant has well said:

"Truth crushed to earth shall rise again;
The eternal years of God are hers."

contact, and that there must be contact with the entire area covered by the base-plate.

The technic of the methods involved with these modern methods will be presented in this chapter, and the philosophy of the methods will be discussed in the chapter on Retention.

MATERIALS.

The materials used for taking impressions, making casts, and occlusion and contour models need careful consideration. that they may be intelligently manipulated, thereby securing the best results.

There are two classes of material used for taking impressions: First, those substances made pliable by heat and that harden on cooling; and second, materials made plastic with water and that harden by crystallization. Wax, modelling compound, and gutta-percha are the materials of the first class, while plaster of Paris is the one material of the second class.

Wax.—Wax is a general term applied to a solid fatty substance obtained from all three of the kingdoms of matter. The general properties of the various substances called wax may be stated thus: They are solid or semisolid substances; are easily broken when cold, but at a moderate heat are soft and pliable, and fuse at a temperature below 212° F. They have a peculiar glistening appearance, are lighter than water, are insoluble in that fluid and in cold alcohol, but dissolve readily in ether; they are combustible, burning with an illuminating flame, and are non-volatile.

Beeswax.—Beeswax is an animal secretion formed by bees from sugar, and is the material of which the honeycomb is formed. It is obtained by expressing the honey and fusing the residue in water. In this state it is of a yellowish color (Cera flava). It may be bleached, so as to form white wax (Cera alba), by being exposed in thin slices to the action of solar light. The yellow wax is firm, breaking with a granular fracture, yellowish, having an agreeable honey-like odor; not unctuous to the touch; melts at about 175° F.; is insoluble in alcohol, but dissolves in oil of turpentine,

ether, and chloroform. It is of a complex formation, and a number of derivatives are obtained from it. $C_{48}H_{92}O_2$ is considered as its general composition.

Vegetable Wax.—These waxes may be obtained from several varieties of plants. They are of no value to the dentist.

Mineral Wax.—This is a natural material known as ozocerite, and is a waxy translucent mixture of the paraffins of coal formations. The paraffins have a chemical formula of C_nH_{2n+2}. The natural mineral wax (earth wax) may be used, but the manufactured mineral wax (paraffin, a by-product of the distillation of coal and petroleum) is extensively used in the dental laboratory. It is used in sheet form as base-plate wax, also combined with beeswax.

Wax is softened for use by heating in hot water or a flame, and kneading with the fingers. If the wax is to be softened in water, small lumps should be placed in a dish containing a quart or two of cold water, then as the water is heated the heat will penetrate the wax and not melt the surface only, as would be the case if the lumps of wax were placed in hot water. As the wax softens it is removed from the water, dried upon a cloth and kneaded between the fingers until it is smoothly plastic. Should the softened wax become too hard for its intended use it may be again warmed in the water or passed a few times through a smokeless flame. The dry-heat method of working wax consists in having the wax from $\frac{1}{16}$ to $\frac{1}{4}$ inch thick and passing it repeatedly through the Bunsen flame and kneading between the fingers. It is reheated and kneaded until it is of the proper plasticity. Should it be overheated upon the surface it will appear crumbly, but soon becomes smoothly plastic by kneading. Beeswax adulterated with tallow may be detected by the odor and greasy feeling. Such wax is not desirable for dental purposes.

Wax may be easily made into sheets of any thickness by the dipping method. The wax is melted over water in a double pan (that is, one pan set in a larger pan containing water, thus lessening the danger of ignition); when it is thoroughly melted and any dirt it may have contained has settled, a flat quart bottle containing cold water is dipped

into it and instantly removed. When the layer of wax upon the surface of the bottle has chilled, it should be slit upon the sides and at the edge of the bottom of the bottle, when it can be stripped from the glass. Sheets of varying thickness may be made by dipping repeatedly.

Modelling Compound.—This material is a composition of a resinous gum, as copal, dammar, etc., with stearin and French chalk, colored and flavored.

In the *Zahnärztliche Rundschau*, Berlin, January, 1913, Dr. F. Schoenbeck, of Leipzig, says:

"The plastic impression materials used in dentistry are composed chiefly of resin and stearin, to which, for the sake of obtaining a certain consistence, fillers, such as talcum, are added. Some dyestuff and a few drops of an ethereal oil improve appearance and taste. Under a low-power microscope these materials present the picture of a uniform surface, permeated with fatty acid needles, particles of coloring matter and grains of the filler employed. Besides these we observe more or less dissolved resin particles, which are easily recognized by their yellow color. The size of these resin particles directly influences the plasticity of the material, which should possess the following properties: It should soften at a temperature higher than that of the mouth, should possess great plasticity, uniform structure, should give a sharp impression, should not stick, should harden quickly in the mouth, and should not contract or expand to any great extent, though a slight expansion is not detrimental. The temperatures at which the various impression materials tested became soft and workable varied between 41° and 45° C. The size of the grain of the filler employed greatly influences the plasticity of the material. The amount of contraction in an impression compound can be determined: First (and unsatisfactorily), by a ruler and calipers; second, by the micrometer. The tests carried out by the writer with the micrometer method showed, in the various brands examined, a variation in contraction of from 0.005 to 0.035 mm. For very delicate measurements he uses a telescope, the lens of which is provided with a micrometer scale.

"On the whole, the volumetric changes in impression materials do not differ very widely, since a difference in temperature of only about 20° is to be reckoned with, the various materials being workable at from about 40° to 60° C.

"If placed in boiling water, the composition of modelling compound is altered entirely. Fatty acids and resin particles are dissolved or melted out; and the change in the quantitative ratio of the materials contained in the compound naturally alters the physical behavior of the mass.

"In order to obtain a homogeneous, plastic mass, the softened compound should be kneaded thoroughly, microscopic examination showing a much more uniform distribution of the filler in the kneaded mass. Kneading also discloses any large particles of resin which may be imbedded in the compound, and which can be easily removed before taking an impression."

A formula and instruction for compounding, attributed to Mr. E. Lloyd Williams, of London, England, is as follows: French chalk, $1\frac{3}{4}$ parts; kauri, 1 part; stearin, $1\frac{1}{2}$ parts. Melt the stearin in an enamelled pan and stir in the gum. When these are thoroughly incorporated stir in the chalk. This material will be of a yellowish-white color. It may be colored with carmine and flavored as desired. Modelling compound is much used in taking impressions, for trial base-plates, and occlusion and contour models.

Modelling compound is softened in water after the manner described as the wet method for softening wax. The surface of the compound, just before placing in the mouth, should be passed over a flame. As the softened modelling compound is liable to adhere to the bottom of the pan, it is a good plan to place one end of a strip of white paper in the pan for the compound to rest upon. The other end is a convenient means for withdrawing the compound from the hot water.

Gutta-percha (*gatah*, gum; *percha*, the tree from which it is obtained).—The gum is in many respects similar to caoutchouc. The former is only slightly elastic, while the latter has almost perfect elasticity. Gutta-percha is the dried milky juice of a tree, *Isonandra gutta*, growing in the Malayan Archipelago. The material may be had at the dental

supply houses in sheet form. It is considerably used for trial base-plates, and formerly was much used for taking impressions. Its use for this purpose has been, of late years, superseded by modelling compound, a superior material.

Plaster of Paris.[1]—Plaster of Paris is made from the mineral called *gypsum*. This mineral is found in various forms, as *massive* or *rock* gypsum; *alabaster*, a pure white, fine-grained massive gypsum; and *selenite*, a crystalline, almost transparent gypsum. The chemical composition of pure gypsum is $CaSO_4+2H_2O$. Therefore pure gypsum is a hydrous sulphate of lime, made up of one molecule of calcium sulphate combined with two molecules of water. This, when reduced to percentages of weight, corresponds to the following:

$$\text{Gypsum } (CaSO_4+2H_2O) = \begin{cases} \text{Lime sulphate } (CaSO_4) & 79.1 \text{ per cent.} \\ \text{Water } (H_2O) & 20.9 \text{ per cent.} \end{cases}$$

$$\text{Lime sulphate} = \begin{cases} \text{Lime } (CaO) \\ \text{Sulphur trioxide } (SO_3) \end{cases}$$

Gypsum is rarely found chemically pure. The usual impurities are silica, alumina, iron oxide, calcium carbonate, and magnesium carbonate. Usually these impurities do not attain a volume of 3 per cent., and are often less than 1 per cent. Gypsum is prepared for the market by grinding and burning, and mixing with accelerators and retarders. The products of manufacture are designed for a definite purpose, and cannot be interchanged advantageously. The dentist should have a general knowledge of the various gypsum products, so as to select his plasters intelligently.

Classification of Plaster.—"*A*. Produced by incomplete dehydration of gypsum, the calcining being carried on at a temperature not exceeding 400° F.

"1. Produced by the calcining of a pure gypsum, no foreign material being added either during or after calcining. *Plaster of Paris.*

[1] The authorities for this general sketch of plaster of Paris are: Cements and Plasters, by Edwin C. Eckel, C.E., published by John Wiley & Sons, New York, 1907: Calcareous Cements, by Gilbert R. Redgrave and Charles Spackman, published by Charles Griffin & Co., London, 1905.

"2. Produced by the calcining of a gypsum containing certain natural impurities, or by the addition to a calcined pure gypsum of certain materials which serve to retard the set of product. *Cement plaster.*

"*B*. Produced by the complete dehydration of gypsum, the calcination being carried on at a temperature exceeding 400°

"3. Produced by the calcination of a pure gypsum. *Flooring plaster.*

"4. Produced by the calcination, at a red heat or over, of gypsum to which certain substances (usually alum or borax) have been added. *Hard-finish plaster.*"

In the trade these names are used extensively, but at times in a careless and indefinite fashion. *Calcined plaster* commonly means a burned plaster to which no retarder has been added. It may be either *plaster of Paris* or *cement plaster.* *Stucco plaster* is less finely ground than plaster of Paris, and usually is not made of as pure a quality of gypsum. *Wall plasters* are made by adding not only a retarder, but some kind of fiber, to calcined plaster. Keene's, Martin's, and Mack's cements are *hard-finish plasters* variously treated with such substances as alum, borax, borax and cream of tartar, potassium carbonate, and potassium or sodium sulphate.

Chemistry of Gypsum Burning.—If pure crude gypsum is heated to a temperature of more than 212° F., and less than 400° F., a certain definite portion of the water of crystallization will be driven off, and the gypsum thus partially dehydrated will be plaster of Paris. Plaster of Paris has the formula $CaSO_4+\frac{1}{2}H_2O$, which equals calcium sulphate ($CaSO_4$), 93.8 per cent., and water (H_2O), 6.2 per cent. Dehydration to this extent can be accomplished at any temperature between 212° F. and 400° F., but for economy of fuel and time it is usually carried on at the highest allowable temperature; and 330° to 395° may be regarded as the usual limiting temperature for plaster manufacture. The late Prof. Essig stated that "the highest-grade dental plaster is calcined at about 261° F." The writer has been unable to confirm this statement, for the manufacturers refuse to give this information, saying that the temperature used is their

trade secret. Several of the manufacturers state that their dental plasters are calcined from the purest selected rock obtainable, and that no accelerator nor retarder is added. It is quite probable that the difference in the various dental plasters upon the market is largely physical and not chemical; and are dependent upon: (1) degree of dehydration; (2) degree of pulverization, and (3) blending plasters of various degree of dehydration and pulverization. About 400° F. is a critical temperature, for if gypsum be heated much above this it loses *all* of its water of crystallization, becoming an anhydrous sulphate of lime, and useless as a normal plaster. Under certain conditions, however, "dead-burned" gypsum gains certain properties, and forms flooring and hard-finish plasters. Partially dehydrated gypsum has the property of taking up the lost water of crystallization and setting or recrystallizing. If the gypsum is pure and unmixed with retarder, the setting of the plaster will be complete in a few moments, while dead-burned plaster, as such, is spoken of as non-setting; however, it does set, but requires hours for the initial set and weeks for complete hydration.

There are three methods of calcining gypsum, known as the kettle, oven, and rotary-cylinder processes. So far as the writer has been able to learn, the kettle process only is used in America for manufacturing dental plasters; but the rotary cylinder is extensively used for building plasters. It is reported that the oven and kiln are in vogue in Europe and England. The rotary-cylinder process is an improved method of recent years.

Grinding of Gypsum Products.—Grinding is an important factor in the manufacture of gypsum products. In the kettle process the rock is first ground and then roasted, while in the oven and the rotary-cylinder processes the rock is broken into convenient-size masses, roasted, and then ground. The use for which the plaster is designed will determine its fineness. However, it is a factor only, as the finest plasters to be obtained are much slower setting than some coarser-ground ones. Eckels states that: "A dust chamber located above the rotary calciner catches the most finely ground

plaster, which is marketed for dental plaster and other special purposes."

The Theory for the Setting of Plaster.—M. Le Chatelier has formulated a new theory, based upon the phenomena of supersaturation investigated by Marignac. This observer has shown that: "Hydrated calcium sulphate with half an equivalent of water, which remains undecomposed at a temperature of about 310° F., dissolves freely when shaken up with water, but that after a short interval the solution becomes turbid. This is due to the formation of a crystalline precipitate of the common hydrate with two equivalents of water, which has the formula of gypsum. The solution formed in the first case is five times as concentrated as that made from the less completely hydrated sulphate. It would appear from this that the most important agent in the accomplishment of the setting process is the relatively soluble hydrate, namely, that with a small percentage of water. This hydrate is at once dissolved, and then gives rise to the formation of the other hydrate, with the full equivalent of water. The latter compound decreases the solubility of the mixture, and the water becomes supersaturated with the $CaSO_4 2H_2O$ hydrate, which crystallizes out. This process continues so long as there remains any of the soluble hydrate [2 $(CaSO_4)H_2O$] to fortify the solution.

"The set of plaster is thus the result of two distinct series of operations, which take place simultaneously: First, the particles of calcium sulphate in the act of hydration are dissolved in the water used to gauge them, and produce a supersaturated solution; the solution thus formed deposits crystals of the hydrated sulphate. These crystals gradually increase in size, and form a compact mass in the same way as do all similar crystals deposited slowly from a saline solution, and this process is continued as long as any of the more anhydrous sulphate remains available to become dissolved and to keep the solution supersaturated."

Properties of Dental Plaster.—Gypsum products, to be suitable for dental purposes, should possess certain properties, and a special brand is of value only as it meets the requirements. It should be free of all foreign substances (as dirt

and fibrous matter), sufficiently ground to form a smooth mix, quick setting, generate but little heat, minimum of change of form while crystallizing, and sufficiently resisting to any stress to which it may be subjected.

There are three different requirements of practice that make a demand for as many classes of plaster: (1) for impressions the plaster should be quick setting, expand but little (not contract), and easily broken; (2) for casts the plaster should be as little changeable while crystallizing and under stress as possible; and (3) for flasking and luting a medium between the preceding two is required. However, the first class of plaster may well, and can, be dispensed with by adding a chemical substance to a well-chosen third-class plaster, and is used for impressions.

In fact, a strictly impression plaster is a dangerous article in the laboratory, as it is unfit for casts and flasking and is too apt to be improperly used. The addition of sodium chloride or potassium sulphate to a high-grade suitable plaster for flasking answers well for impressions.

See pages 74, 76, 77, and 78 for two tabulations designed to illustrate the physical and working properties of, as it is believed, the leading brands of dental plaster used in America, England, and Europe:

The first table has to do with the amount of moisture absorbed from the atmosphere after calcining and the percentage of the degrees of fineness of the product. Fifty grams of plaster is dried and weighed to ascertain the percentage of moisture that has been absorbed. It is then placed in a tier of sieves and racked for five minutes, when each portion is weighed and expressed in percentage. The plaster is permitted to stand exposed to the atmosphere of the room, when it is again weighed, and the loss represents the amount of moisture not reabsorbed, and the loss of material in handling, which is the larger part of the loss. The last column indicates time in hours. The first line of data may be read: French's impression plaster (White's is the same); dried for two and one-half hours at a temperature varying from 220° to 240° F., lost 3.7 per cent. (moisture), and after sieving there remained 5.68 per cent. of plaster

upon the 50-mesh, 21.80 on the 100-mesh, 46.07 on the 150-mesh, 24.77 on the 200-mesh, and 1.11 on the bottom.

TABLE I.

Degree of pulverization.	Dried degrees F. Time in hours.	Per cent. of dehydration.	Top 50-mesh, per cent.	Top 100-mesh, per cent.	Top 150-mesh, per cent.	Top 200-mesh, per cent.	Bottom, per cent.	Loss of material.	Time of last weighing.
French's Impression White's Impression	220 245 2½	3.70	5.68	21.80	46.07	24.77	1.11	1.48	24
French's Regular White's Cast	220 245 2	3.30	7.83	34.45	45.17	12.28	0.25	1.18	18
French's Slow	240 264 2	3.32	7.29	31.60	52.67	7.14	1.26	1.60	15
Spence Plaster Compound	216 222 3½	3.04	16.35	49.60	26.05	6.34	1.44	1.80	48
Newburg Green Star	260 1	6.50	3.10	10.24	34.73	34.90	17.27	1.66	40
King's	220 230 3	3.40	1.05	22.64	43.19	23.38	9.71	1.56	30
Keystone Impression	260 2	6.30	0.21	2.18	19.73	27.81	49.81	1.68	27
Keystone Cast	300 3	5.18	1.23	8.78	41.75	38.53	9.68	1.88	48
Nephi, Utah	220 2	2.00	3.69	14.27	21.64	24.07	36.32	0.90	23
Demare, Chartier & Co., France, Impression and Cast	200 240 3	2.86	4.72	57.22	35.63	6.22	2.19	3.26	12
Rapp & Reitenbach, France, Casts	230 240 3	4.38	5.28	35.61	42.87	12.90	3.31	4.66	1
The Gips-Union, Zurich Casts	220 245 4	5.06	0.42	21.22	44.88	22.66	10.85	5.76	1
Stolnbrook, Germany, Casts	220 240 5	0.50	2.81	16.15	27.87	23.61	29.56	0.60	1
Alabaster Gips, Germany	220 240 4	2.73	7.02	52.57	36.70	3.11	0.57	0.48	48
Mountain & Son, Leeds, England, Casts	230 2½	6.50	16.80	53.77	19.58	4.65	4.96	3.46	22
Bellman, Joey & Carter, London, Impression	200 240 3	3.04	15.65	58.16	23.63	2.60	0.35	2.06	18

Twenty-four hours later there was a loss of 1.48 per cent. of the original 50 grams of plaster.

The second table records experiments in setting, contraction and expansion, and compression. The first column indicates the brand of plaster, the ratio of water to plaster, and, if an accelerator is added, the number of grains (Troy) to the ounce (weight) of water. The second and third columns indicate the number of minutes for initial and hard set respectively. The upper figure in the fourth column is the number of points (0.0001 of an inch) contraction to the lineal inch, and the lower figure the number of minutes in which contraction took place. The fifth column is the number of minutes elapsing between placing the plaster in the instrument and the beginning of expansion; the following three columns, the number of points of expansion to the lineal inch in fifteen, thirty, and sixty minutes respectively. In the next column the upper number indicates the points of expansion attained in the time (hours) expressed in the lower number. The following four columns give the amount of compression in twenty minutes, thirty minutes, one hour, and twenty-four hours after mixing, upon a confined mass of plaster approximately nine-tenths inch thick. The upper figures indicate the number of pounds pressure applied to a circular surface one-half inch in diameter, and the lower figures the percentage of compression. In the remaining two columns the figures indicate weight, percentage of compression and time. The setting time was ascertained by aid of the Gilmore needles. When the setting plaster will sustain, without indentation, a needle weighing $\frac{1}{4}$ pound upon a point $\frac{1}{12}$ inch diameter it is said to have attained initial set; and when it will sustain the needle of 1 pound weight upon a point of $\frac{1}{24}$ inch diameter it indicates hard set. The instruments for measurements of contraction, expansion, and compression are well made and reasonably accurate; certainly the resulting figures are equitable for comparison, subject to the personal equation of the operator only, which was the writer. The figures under the name of the brand of plaster indicate the ratio of water and plaster by weight, as water 1 part and plaster from $1\frac{1}{2}$ to 4 parts as indicated. The amount of accelerator indicates the number of grains to the ounce (Troy) of water.

TABLE II.

	Initial set, minutes.	Hard set, minutes.	Contraction. Points and minutes.	Expansion began in minutes from mixing.	Expansion 15 minutes from mixing.	Expansion 30 minutes.	Expansion 1 hour.	Expansion. Points, hours.	Compression 20 minutes. Weight and per cent.	Compression 30 minutes. Weight and per cent.	Compression 1 hour. Weight and per cent.	Compression 24 hours. Weight and per cent.	Compression. Weight, per cent. and hours.
French's Impression, 1 to 1½	4	8	4 1½	6	14	19	20	20 3	500 3.39	500 2.39	500 2.61	500 4.61	1000 30.86 24
French's Impression, 1 to 1½ and 5 grs. NaCl	3	6	...	2	15	15	15	..	500 14.64	500 15.03	500 9.24	500 18.16	
French's Impression, 1 to 1½ and 3 grs. K_2SO_4	2½	4	...	1½	9	9	9	12 24	500 11.27	500 8.41	500 11.30	500 11.86	
French's Regular 1 to 2	7½	16	7 2½	7½	6	23	26	28 24	500 10.40	500 0.22	1000 6.06	1000 4.69	2000 35.97 24
French's Regular 1 to 2 and 5 grs. NaCl	3	8	2 1	4	22	25	26	..	500 0.55	500 0.44	1000 11.12	....	2000 37.00 24
French's Regular, 1 to 2 and 3 grs. K_2SO_4	3	7	1 1	4	18	18	18	23 24	500 0.53	500 1.12	1000 8.81	....	2000 39.81 24
French's Regular, 1 to 1½	10	18	4 2	10½	2	14	16	22 24	500 15.00	500 9.27	500 9.08	1000 34.72	
French's Regular, 1 to 1½ and 5 grs. NaCl	7	12	...	4½	12	12	12	10 24	500 9.68	500 11.89	500 8.74	1000 43.18	500 9.48 24
French's Regular, 1 to 1½ and 3 grs. K_2SO_4	5	8	...	4½	8	8	8	..	500 10.99	500 10.56	500 9.52	1000 44.05	500 7.82 24
French's Slow Set, 1 to 2	17½	31½	...	...	..	..	..	..	....	....	....	....	1000 10.64 3½
French's Slow Set, 1 to 2 and 5 grs. NaCl	9	16	2 2	3	6	17	18	18 3	1000 6.31	1000 8.20	1000 7.88	1000 10.27	
French's Slow Set, 1 to 2 and 3 grs. K_2SO_4	6	11½	...	...	..	..	..	..	1000 8.24	1000 8.39	....	1000 8.39	

Spence Plaster Compound, 1 to 3½	15	29	5 4½	30	..	.	3	3½ 2½	500 13 14	1000 0 43	2000 8 67	3000 5 62	
Spence Plaster Compound, 1 to 4	11	...	7 18	30	...	..	4	7½ 17	500 0 36	1000 1.34	....	2000 0 60	
Newburg Green Star, 1 to 2	21	...	.	21	..	11	25	40 24					
Newburg Green Star, 1 to 2 and 5 grs. NaCl	4	..	...	6	.		25	25 24	....	..	500 0 53	1000 26 62	
Newburg Green Star, 1 to 2½	5	15	...	8	5	24	30	34 24	... .	....	500 0 35	1000 1 48	
excess water poured										1000 22 03	1000 23 27	1000 27.87	
1 to 2	18	31	7 13	29	..	2	13	30	.... .	....	1000 12.03	.. ....	1500 35.96 13
King's Knickerbocker, 1 to 2 and 5 grs. NaCl	8	16	...	...	..	..	..	..	.	....	1000 12.56	.... ..	1000 13 47 18
King's Knickerbocker, 1 to 2 and 3 grs. K_2SO_4	12	16	...	...	.	..	.	.	...	....	1000 17 37	.. ....	1000 17.73 18
King's Knickerbocker 1 to 2½	15	29	7 10	21	.	5	20	44 18	...	....	1000 5.61	....	1000 5 02 18
Keystone Impression, 1 to 1½	7	12½	...	4	13	15	15	.	500 23 92	500 21.42	500 36 68		
Keystone Impression, 1 to 1½ and 5 grs. NaCl	5½	3½	...	5	23	..	23	..	500 22 56	. ...	500 29 19		
Keystone Impression, 1 to 1½ and 3 grs. K_2SO_4	4	11	..	8	16	.	16		500 23 59	. . .	500 24 28		
Keystone Cast, 1 to 2	9	21	13 18	21	..	6	28	37 24	....	1000 29 65	1000 24 80	1000 15.43	
Keystone Cast, 1 to 2½	8	16	7 8	14	..	11	22	30 24	.... ..	1000 10 01	1000 5.35	1000 2.30	2000 29.16 24
Nephi Dental 1 to 1¾	8	15	1 1	6½	15	34	30	..	500 0 28	1000 10 76	1000 17 62	1000 13 60	
Nephi Dental, 1 to 1¾ and 5 grs. NaCl	4	8	...	3	26	..	28	.	500 0 90	500 0 76	1000 15 96	1000 21.46	
Nephi Dental, 1 to 1¾ and 3 grs. K_2SO_4	4	6	...	..	20	..	19	.	500 0.84	500 0 52	1000 18 13	1000 19 20	
Demare, Chartier & Co., France, Impression and Casts, 1 to 2	7	16	0	..	7	22	30	35 12	.. ....	500 0 96	500 1 12	1000 12.39	

TABLE II—Concluded.

	Initial set, minutes.	Hard set, minutes.	Contraction. Points and minutes.	Expansion began in minutes from mixing.	Expansion 15 minutes from mixing.	Expansion 30 minutes.	Expansion 1 hour.	Expansion. Points, hours.	Compression 20 minutes. Weight and per cent.	Compression 30 minutes. Weight and per cent.	Compression 1 hour. Weight and per cent.	Compression 24 hours. Weight and per cent.	Compression. Weight, per cent. and hours.	Compression. Weight, per cent. and hours.
Rapp & Reitenbach, France, Cast, 1 to 2	16½	26	2 20	23	..	2	17	25 24	....	....	1000 17.08	1000 20.56		
Rapp & Reitenbach, France, Cast, 1 to 2½	14	23	1½ 22	23	..	1	20	24½ 24	....	....	1000 1.00	1000 1.13		
Gips Union, Zurich, Cast, 1 to 2	9½	17½	...	...	..	..	..	..	....	....	500 0.60	1000 24.55		
Gips Union, Zurich, Cast, 1 to 2 and 3 grs. K_2SO_4	...	11½	...	...	13	18	..	18 24						
Gips Union, Zurich, Cast, 1 to 2½ . . .	5	8½	...	6	8	20	27	..	....	500 0.44	1000 2.70	1000 2.15		
Stolnbrook, Berlin, Cast, 1 to 3½	30	...	...	...	..	..	..	....	....	....	....	2000 1.30	1000 0.31 13	2000 2.36 13
Stolnbrook, Berlin, Cast, 1 to 3½ and 5 grs. NaCl	29	...	...	...	..	..	..	.. •	....	....	....	2000 2.26	1000 0.75 24	
Stolnbrook, Berlin, Cast, 1 to 3½ and 3 grs. K_2SO_4	28	60	35 60	...	..	..	..	13 24	....	....	500 No resist.	2000 0.68		
Alabaster Gips, Berlin, 1 to 2	7	12	0	...	14	28	32	44 24	....	....	1000 8.12	1000 6.63		
Alabaster Gips, Berlin, 1 to 2 and 3 grs. K_2SO_4	3½	6	0	...	20	24	24	27 24	500 2.02	500 1.21	500 2.30			
Alabaster Gips, Berlin, 1 to 2½	4½	7½	3 4½	5	24	35	38	5057 2442	500 0.20	1000 2.73	1000 3.34	1000 1.40		
Mountain & Son, Leeds, Cast, 1 to 2½ . .	7½	11½	0	...	12	32	42	51 24	....	1000 13.78	1000 12.45	1000 9.37		
Bellman, Joey & Carter, London, 1 to 2 .	8½	15½	2 7	8	8	17	24	40 20	....	500 1.03	500 0.46	1000 11.07		
Bellman, Joey & Carter, London, 1 to 2 and 5 grs. NaCl	4½	7	8 5	.:.	20	..	24	..	....	500 0.72	500 0.57			

The method of mixing consisted of placing the weighed water (and accelerator when used) in the bowl into which the entire amount of plaster to be used for the mix is placed and quickly agitated with a spatula until smoothly mixed; however, avoiding excessive stirring. The impression plasters are treated only with a mix of 1 of water to 1½ of plaster, as this is the best consistency for impression taking. For all other uses (than impressions) plaster should be mixed thicker, and when but one mix of a brand of plaster is tested it is the one the writer believes is the best for the brand. In studying this chart it is well to keep in mind that the lower the contraction and expansion the better for all uses; but in strength (as indicated by compression), a weak plaster is desired for impressions, and for all other purposes the stronger the plaster the more desirable. (Notice that the strength of the plaster decreases with the increased percentage of compression.) It is obvious, from this chart, that the larger the ratio of plaster to water the quicker setting and greater strength; also, unfortunately, the greater expansion. Also, that the addition of sodium chloride hastens the setting and reduces the strength, and that potassium sulphate hastens the setting and reduces the expansion and strength.

The plasters manufactured by the S. H. French & Co. are extensively used by the profession in America, therefore careful study should be given them. The impression plaster without an accelerator is quick setting and unnecessarily strong for impression, but too weak for any other purpose. It is very much improved by the addition of accelerator, but is entirely unfit for any purpose other than impressions. The "Regular Dental Plaster" with an accelerator and mixed thin is a very good substitute for the impression plaster. However, it does not set quite so quickly and is a trifle stronger than necessary; nevertheless, it expands less. The slow-setting plaster is a delusion and has nothing to commend it. It is made to comply with certain ideas entertained by the profession in that a slow-setting plaster is stronger and better for casts. It is true it is stronger than the regular dental plaster, but because of its slowness of set the workman is liable to work upon it before it has

attained the strength the regular plaster would have; further, it contracts and expands more than the regular, and cannot compare with the Spence Plaster Compounds for casts.

The Spence Plaster Compound changes form less than any of the pure plasters and attains its maximum strength in one hour; however, it is much stronger in thirty minutes than a pure plaster. The writer commends French's Regular Dental Plaster for all purposes except casts, and without exception Spence Plaster Compound for casts. However, by consulting the table it will be seen that there is very little difference between French's Regular Plaster and several other good brands for general purposes. Hence, if an operator is obtaining satisfactory results with any good brand it is unnecessary, and may be unwise, to change. For casts and casts only, no other plaster in the table compares with the Spence Plaster Compound.

Another interesting experiment is in connection with the hydration of plaster. Gypsum contains 20.9 per cent. of water of crystallization; when partially dehydrated for dental plaster it contains 6.2 per cent. of water. The table shows that French's Regular Dental Plaster loses approximately 3.5 per cent. of its weight (abnormal moisture) when subjected to a "temperature" not exceeding 240° F., thus showing that the plaster ready for the dentist's use contains 9.7 per cent. of water, therefore 9.7 substracted from 20.9 would leave 11.2 per cent., the amount necessary for complete hydration. However, if the quantity of water representing the 11.2 per cent. is placed in a beaker and the requisite amount of dental plaster is added to it without agitation it will eventually be found that there is a small portion in the bottom of the beaker perfectly crystallized, another portion partially crystallized, and the top portion apparently unaffected. If a block is made containing by weight one ounce of water and two ounces of French's Regular Dental Plaster and left exposed until it ceases to lose weight (about twenty-five hours), it will be found that it has lost approximately 22 per cent. of its entire weight. As the loss is water the 22 per cent. deducted from the one-

third (33.33 per cent.) water would show that approximately 11.3 per cent. had combined permanently with the plaster.

The practical points to be derived from these hydration experiments are: that it is impossible to mix dental plaster without an excess of water, that the larger the excess of water the less dense and weaker the plaster, and that the smaller the excess of water the denser and stronger the plaster. Conclusion: that plaster should be hydrated to meet the requirements of the operation.

A New Impression Plaster.[1]—NIELSIN.—A compound of plaster of Paris and starch. The advantage claimed for this is that the impression may be removed from the cast by boiling in water. This phenomenon is explained by the well-known property of starches, that is, that they are insoluble in cold water, but soluble in hot water. The material is used the same as ordinary impression plaster. The subsequent technic is the same as for plaster except the separation of the cast from the impression—which is as before stated.

IMPRESSION TRAYS.

Definition.—A dentist's tray or cup used for holding the impression material while taking an impression of the mouth or teeth. Tray is the better term to use, as it conveys an idea of a utensil having flanges and a capacity to hold and carry, while cup conveys the idea of symmetry of form with a base on which to stand, and holding capacity. Trays are made of various materials and sizes.

Tray Material.—The materials of which trays are made are block tin or alloyed tin, cast and pressed aluminum, German silver, and porcelain. Each material has its advantages and disadvantages, hence for special purposes the tray should be constructed of the material best adapted. While porcelain is the most cleanly material, it is not practical because its form cannot be changed, and it is easily broken. Block tin (or some of its alloys) is most commonly used.

[1] "Byrites" is an imitation of "Nielsin."

The trays made of this material may be readily changed in form, by cutting and bending, which is an essential property.

Tray Nomenclature.—A tray has a *body* and a *handle*. The body consists of a *floor* and *flanges*, and those designed for the upper jaws have a *vault portion*. There are two types of floors—*oval*, for edentulous jaws, and *flat*, for accommodating remaining teeth. The flanges are called *outer* and *inner*. The outer flange has two portions, the anterior or labial, and the posterior or buccal. The dividing line is the proximity of the distal surface of the cuspid tooth. The inner flange is also called the lingual flange. The surfaces of the tray are named for the surfaces they approximate, as maxillary, labial, buccal, and lingual. (These terms are used also in base-plate nomenclature.) The term palatal surface is used indiscriminately, meaning either the maxillary or lingual surface. The term is confusing, and should be avoided.

The vault portion spans the space described by the curve of the lingual flange of the upper tray.

The handle is an extension from the union of the floor and the anterior flange. The handle is designed to be used while carrying the tray into the mouth; also for removing the tray and impression from the mouth. The handle should never be used for holding the tray while the impression is hardening, as it acts as a lever, and it is almost impossible to avoid enlarging the intaglio of the impression.

Tray Forms.—The form of the tray should be such as to approximate the form of the part of which the impression is to be taken. This would require a great variety of trays, therefore it is desirable to have the trays constructed of a material that can be readily adapted to the individual case. These changes are made by cutting away the undesired portion, or by bending in or out the portion not properly adjusted; or the desired form may be obtained by adding some plastic adhesive material, such as wax or modelling compound. This added material should not be considered as a part of the impression, but as a part of the tray only as the surface outline of the built-up tray would be such as a specially constructed one should have. In fact, some prosthetists have advocated taking a crude impression and

FIG. 18

FIG. 19

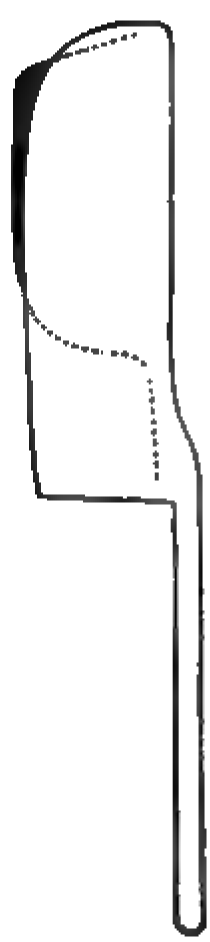


FIG. 20

making a plaster cast, from which a tray is constructed.[1] This tray would have the advantages of requiring but a small amount of impression material, and of carrying it accurately into place. Such methods require too much time and work, and do not meet the requirements of really difficult cases. The metal tray should approach equally all the

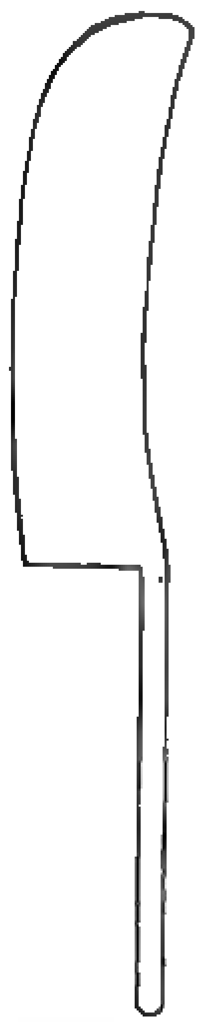


Fig. 21

surfaces to be impressed. There should be a space of about one-eighth of an inch to be occupied by the impression material. This will give sufficient body of material for strength, and in case of fracture of the impression the pieces are thick enough to be readjusted. The exception to

[1] Dr. Bean's method, Turner's American Text-book.

the one-eighth-inch rule is where compression of the soft tissues is required. In such cases no stock tray could answer the purpose; but a simple stock tray may be reinforced so as to perfectly meet the requirements. It is wise to reject all fanciful and complicated trays, depending entirely upon the simplest forms. The various forms of stock trays are made

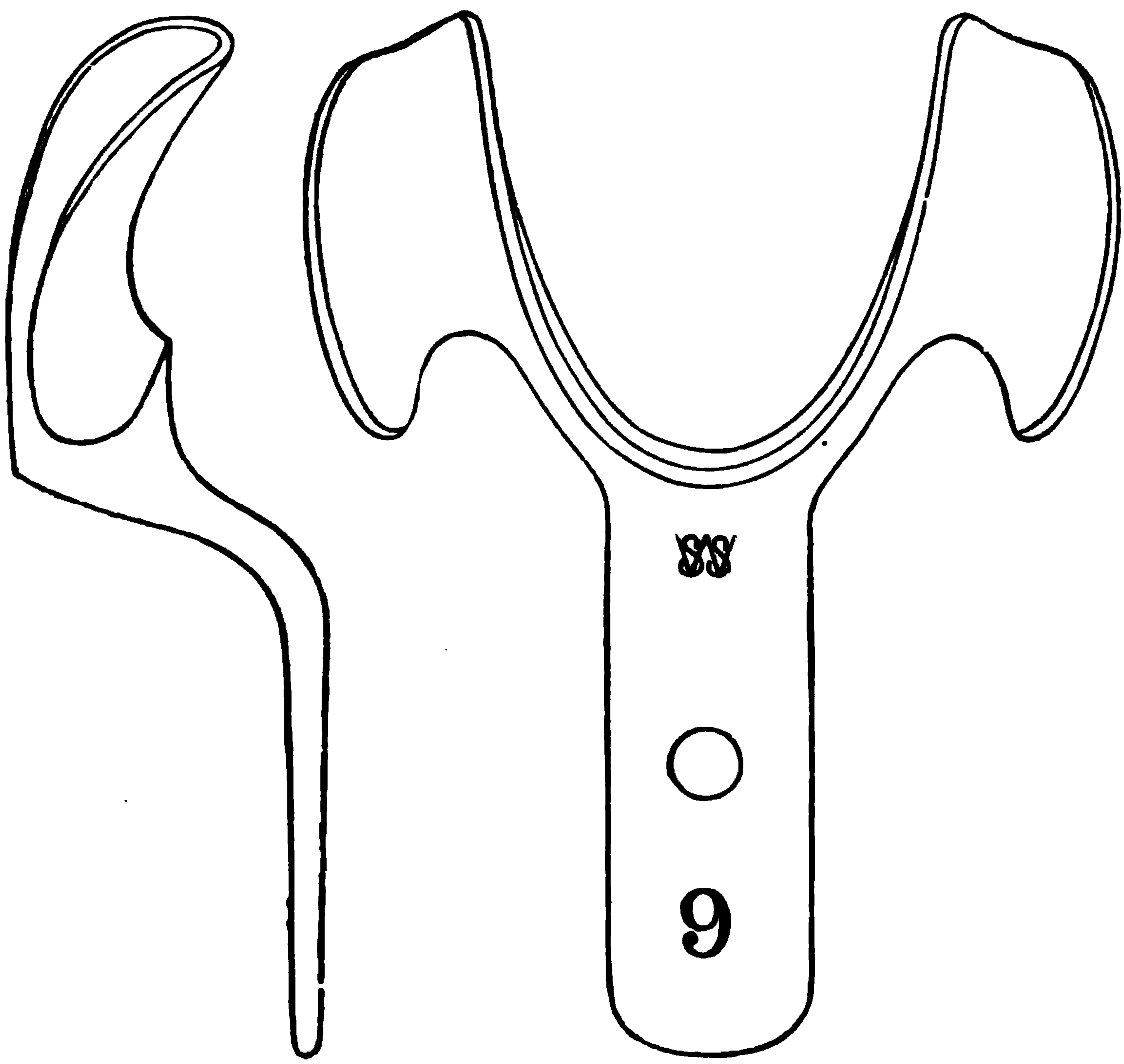


FIG. 22

in several sizes. The student or young practitioner should select a few sizes of each of the primary forms, and, as necessity requires, extra sizes, special forms and duplicates may be added to the equipment. The several manufacturers offer similar lines of trays, and each may have some special and fanciful forms, but these should not interest the student.

For the purpose of illustration, the well-known S. S. W. trays have been selected. These are made of the best quality of Britannia metal, and will meet all ordinary requirements. Fig. 18 shows an upper tray of the oval floor type. There are eight sizes of this type, numbered from 1 (largest) to 8 (smallest). For the first outfit sizes 2,

Fig. 23

Fig. 24

4, and 6 will suffice. Fig. 19 illustrates the lower trays of this type. There are seven sizes, of which 1, 3, and 7 are good selections. Fig. 20 represents the flat-floor type. There are five sizes for the upper jaw, numbered from 12 to 16. Nos. 12 and 15 should be the first selected. Fig. 21 shows a lower tray of the flat-floor type. The largest and smallest of the sizes, 14 and 16, will well complete the initial

collection of trays. While the prosthetist can adapt the ten trays recommended to meet every requirement that may be present, it is well to have some special trays. The most desirable of these are shown in Figs. 22, 23, and 24. The first two are designed for the lower jaw only, while the last one, because of its swivel joint, may be used in any part of the mouth for any small impression.

NOTICE.—The following classification and technic for taking plaster impressions has in no way been changed from the former editions of this book except in the technic for the class in which modelling compound was recommended; and, modelling compound for impressions has been placed in a section by itself.

However, to derive the greatest benefit from this classification and technic the operator must comprehend the modern trend of thought, and have a clear understanding of the *extent to which the impression shall be taken; also, that the soft tissues under the entire periphery of the impression must be held firmly against its bone foundation.*

The peripheral border of the upper impression under the lip and cheeks may be high or low according to the operator's conception for esthetics, provided it is sufficiently high for the lip and cheeks to seal it against ingress of air. *The vital point is the palatal border. There must be compression of yieldable soft tissue of at least one-fourth-inch width* extending from the buccal side of one tuberosity to the buccal side of the other tuberosity.

The peripheral border of the lower impression must just include the *external and internal oblique ridges.*

TECHNIC FOR FULL UPPER IMPRESSIONS.

Classification
- Normal.
- High vault.
- Flat vaults
  - Thin and tense tissues.
  - Medium soft tissues.
  - Soft and flabby tissues, ropy secretions.
- Enlarged raphé.

Application.—We will suppose we have an edentulous patient in the chair. The patient's comfort having been looked after by adjusting the chair, placing suitable protection for the clothing, and with a glass of water upon the bracket table; the examination of the mouth having been made as described in Chapter I, the case being a "normal" one in every respect, will indicate that plaster impressions are required. The case being of average size will require the oval-floor tray No. 4. The tray should be tried in the mouth to ascertain if any alteration is required. As the aperture of the mouth is less than the width of the palatal end of the tray, it will require suitable manipulation for its insertion. This is accomplished by the operator standing erect, at the right and a little back of the patient; the patient's chin should be about on a level with the elbow when the chair and patient's head are each slightly tilted backward. The patient is instructed to open the mouth moderately wide, when the tip of the index finger of the left hand is placed in the left angle of the mouth. The tray is grasped by its handle between the thumb and first two fingers of the right hand. The anterior portion of the right buccal flange of the tray is placed in the right angle of the mouth, and while distending the lips the tray is swung into the oral cavity. The palatal border of the tray is carried upward over the tuberosities; at the same time the anterior portion of the tray should be depressed sufficiently to permit a view of the relation of the palatal border of the tray with the tuberosities and vault.

Adjusting the Tray.—Should the flanges be too close to the tuberosities, they may be bent outward by grasping the body of the tray in the left hand, and the use of a pair of 4- or 5-inch smooth-nosed pliers in the right hand. By the same means the flanges may be brought nearer to the tuberosities. Should the vault portion impinge, it may be depressed by striking a few times with a horn mallet. (See Metal Platework Implements, Chapter XI.)

Fig. 25 exhibits a tray with an extreme amount of bending of the flanges outward, and the vault portion slightly depressed. In very flat mouths the base-plane may be very

broad, when it would be desirable to have the flanges bent outward rather than cut away.

The anterior flange should next be inspected. Should the tray impinge upon the frænum labii, relief should be afforded by deepening the notch in the tray by use of a half-round file, such as is used in vulcanite work. The flange at either side of the median notch may require adjusting, and often should be cut away. This flange should not obstruct free

Fig. 25

manipulation of the impression material. It would be advantageous if this portion of all prosthetic trays were largely cut away. The student should keep this axiom in mind, that it is better to have the flanges cut away too much rather than not enough, for they may be easily reinforced.

Reinforcing the Tray.—This may be done with either wax or modelling compound. The writer much prefers pure yellow beeswax. This is done by softening a strip of wax

by the dry-heat method and making it into a roll a little larger than the shaft of a lead-pencil. The palatal border of the tray is slightly warmed in the flame and the roll of soft wax is formed upon the maxillary surface, permitting the ends of the wax roll to extend around the tuberosities. This is placed in the mouth and forced firmly to place. The tray is then removed from the mouth, the wax made cold,

Fig. 26

and any excess removed with a hot wax spatula or knife. As has been stated, this reinforcement of wax is in no sense a part of the impression; it should be considered only as an integral part of the tray. This peripheral reinforcement serves a double purpose: first, it acts as a dam to prevent the soft plaster extending too far backward, and second, it acts as a compress to prevent the contraction of the palate muscles

drawing down or depressing the palatal portion of the impression. Inattention to this portion of the impression often causes failure in the retention of the denture. Fig. 26 illustrates the tray with wax reinforcement of the palatal border. The reinforcement may extend forward upon the buccal flanges to include the malar processes, but it should not extend so far forward as to include the buccal frena. However, if the reinforcement extends over the malar process it should be properly adjusted. This is done as follows: When the tray with the peripheral roll has been forced into place, the tray is supported by firm pressure of the index finger of the left hand placed upon the center of the lingual surface of the vault of the tray; when the right cheek is grasped and drawn downward by the index finger and thumb of the right hand, the cheek is released and instantly pressure is made with the fingers upon the cheek over the wax. The left index finger is replaced with the right one, when the left cheek is manipulated in like manner. This illustration shows also the frenal notch sufficiently cut away to prevent impingement, and the labial flange properly adjusted. The tray is now prepared for the case in hand, and could not be improved upon even if a new metal tray were to be made for this individual case.

Changing the Position of the Patient.—The tray being properly prepared for the impression, it is well to change the position of the patient to an upright position with the head slightly inclined forward. This is simply a precaution to prevent any plaster falling into the throat. However, an experienced operator may keep the patient in the first position for his own convenience, and be justified in so doing because of his expertness; but not so with the inexperienced operator.

Mixing the Plaster.—One fluidounce of water, of the temperature of the room or a little warmer, is placed in a rubber bowl (Fig. 27) and four or five grains of salt (NaCl) dissolved in it. A measure holding 2 fluidounces should be filled with regular dental plaster (French's), but not packed; this plaster should be shaken or sifted into the salted water and gently agitated with the plaster spatula (Fig. 28) until it is

smoothly mixed. The object desired is to get the plaster cement smoothly mixed, free from confined air, and in the mouth as quickly as possible. The time required should be but a few seconds. If a special impression plaster is used in place of French's regular dental plaster, the salt will probably not need to be added, as possibly the manufacturer has added an accelerator. Some operators prefer the use of potassium sulphate (K_2SO_4) in place of common table salt ($NaCl$), but either serves an excellent purpose, the $NaCl$ having the more agreeable flavor.

Filling the Tray.—The mixed plaster should be transferred from the bowl to the prepared tray as expeditiously as possible. The plaster should cover the entire maxillary

Fig. 27

surface of the tray; it should be flush with the palatal reinforcement and piled up somewhat at the anterior vault portion.

Inserting and Placing the Filled Tray.—The filled tray should be instantly inserted into the oral cavity, using the technic previously described in this chapter. While the thumb and index finger support the tray, the second finger should be carried backward against the vault of the tray. This will favor carrying the palatal border of the tray firmly into place. While placing the palatal border of the tray the index finger of the left hand is slipped forward under the lip, which is grasped between the finger and thumb, and the lip distended. As the palatal border of the tray is held securely in

position, the anterior portion of the tray is carried into place by a swinging upward movement of the hand. Instantly the

Fig. 28

median portion of the lip, which is in the grasp of the finger and thumb of the left hand, should be drawn downward, thus setting the frenum labii in the soft plaster. The finger is then slipped backward to the left angle of the mouth, which is grasped and drawn downward, marking and placing the buccal frenum. Either the first or second or both of these fingers of the left hand are placed against the vault of the tray, thus releasing the right hand. The right angle of the mouth is now drawn downward, thus placing the right buccal frenum. While firm pressure is maintained upon the vault of the tray, the *cheeks and lips are firmly pressed against the soft plaster with the thumb and fingers of the right hand.* By this means the soft tissues of the buccal and labial walls of the maxilla are compressed. No effort need be made to compress the plaster over the malar processes, as the wax reinforcement will provide for this. Furthermore, if there is any portion of the periphery of the plate which should not press firmly, it is that over the malar processes. The fingers of the right hand may now relieve the left hand, which is placed upon the top of the patient's head. By pressing with both hands, not hard but firmly, the setting plaster is held more steadily in place. If the operator removes a little of the excess plaster upon a finger of the left hand as he removes it from the mouth the last time, he will have a guide as to the hardening of the plaster. It should be left in the mouth (probably two or three minutes) until it will break with a clean fracture, when it is ready to be removed.

Removing the Impression.—When the plaster breaks with a clean fracture and does not crush, the impression should be removed by grasping the handle of the tray with the thumb and fingers of the right hand, while the left cheek is elevated from within with the index finger of the left hand. Pressure is made upon the handle in such a manner as to depress the palatal border of the impression. If the impression does not loosen after a reasonable amount of force has been applied in this manner, a slight rocking movement of the handle up and down may aid. If the operator has left the impression too long in the mouth it may be necessary to throw a jet of water, with a water syringe, around the

periphery of the impression. This is done by tilting the head slightly backward and lifting the lip and cheek upon one side, when the crevice between the impression and the

FIG. 29

FIG. 30

lifted soft tissues is filled with water. The other side of the mouth is treated in the same manner, when the handle should again be manipulated. If the impression is removed at the proper time there will be only moderate adhesion. Strong adhesion of a plaster impression is no evidence that it is a good one, but it is a positive evidence that the plaster has been left so long in the mouth that it has absorbed all the

Fig. 31

moisture from the surface of the mucous membrane, thus creating a powerful vacuum suction, which upon being broken may tear the mucous membrane. With attention given to the work in hand there should be no excuse for such an accident.

Fig. 29 shows the maxillary surface of a plaster impression. Notice the peripheral outline. Fig. 30 shows the palatal border of the impression. Notice the clean cut-off of the

plaster by the wax reinforcement. Fig. 31 is another plaster impression in which the palatal border reinforcement wax has entirely excluded the plaster in places, as can be seen by the difference in color. This illustration shows also the excess plaster pressed forward upon the handle of the tray. The edge of the anterior flange of the tray can be seen much below the periphery of the impression, and yet

Fig. 32

there is much thickness to the labial wall of plaster. This is because the low labial wall of the tray was reinforced with wax, which with the soft plaster was forced against the labial wall of the maxilla by the external pressure upon the lip. In contrast with this, Fig. 29 shows a thin labial wall of plaster, because a higher anterior flange was used with no wax reinforcement. Fig. 32 shows a tray with palatal and

labial wax reinforcements ready to receive the freshly mixed plaster.

The method detailed will suffice for a very large percentage of cases requiring a full upper artificial denture; but there are some cases that will require special manipulation in order to produce the best results. These may be classified as: (1) high vaults, (2) flat vaults, and (3) enlarged raphé.

Fig. 33

High Vaults.—The high vault may be oval, square, or an inverted V-shape. In either case the wax reinforcement should not only be placed along the palatal border, but it should be carried forward to fill the entire vault. After the wax has cooled, the surface of the anterior portion to the thickness of $\frac{1}{16}$ of an inch should be removed with a warmed wax knife. The palatal border should be left undis-

turbed to the width of $\frac{1}{4}$ to $\frac{3}{8}$ of an inch. The object of the reinforced vault portion is to insure the plaster being carried fully to place, and the use of less plaster. Fig. 33 shows a tray prepared for an inverted V-vault. A high vault will always require a high labial flange to the tray. It is better to use a tray with a narrow labial flange, and then build the required flange of wax, thus providing for the compression of the soft tissues over the labial wall of the maxilla. The illustration shows the low metal flange upon the right side and the wax restoration upon the left.

Fig. 34

Flat Vaults.—These cases will present one of three conditions of the soft tissues: (1) thin and tense, (2) medium soft, or (3) soft and flabby. Fig. 34 is a cast of the second class. The impression from which this cast was made was taken in the tray shown in Fig. 25. Obviously a case of this kind would require that the flanges of the tray should be cut away or that they should be bent well over, as shown. The latter is to be preferred, as it provides the desired large base-plane. (This feature will be further considered under the subject Retention of Artificial Dentures.) In both the first and second classes the impression is taken in the usual manner. It is in these flat cases that the student is tempted to omit the palatal border wax reinforcement, but he should remember that the rule is universal, and has no exceptions, that to omit this reinforcement in any case is to invite failure;

however, failure may not come at the bidding. The third class of flat vaults requires special consideration and treatment.

Difficult Flat Vaults.—The flat vault *per se* is not necessarily difficult to cope with, for under favorable conditions it provides the strongest retention. However, there are such a considerable number of vexatious cases associated with flat vaults that they have become the *bête noir* of the dental profession. This is a very unjust condemnation,

Fig. 35

because there are other vault forms that present much greater difficulties. The trouble is that the dentist fails to recognize the conditions, therefore fails to meet the requirements. In the three classes named of conditions of the soft tissues, the first class (hard and tense) presents only the usual difficulties of impression taking; yet the retention in this class is poor. This will be considered in the chapter on Retention. The second class (medium soft tissues), provided the fluids are normal, is one of the most favorable

cases the dentist can have. The third class (soft and flabby) is troublesome and requires study, and suitably taken impressions.

Before entering upon the technic of taking impressions for this class, it is necessary to refer to another factor sometimes associated with flat vaults. A thick, ropy secretion is always a menace to the retention of artificial dentures. This factor is mentioned at this time because one method of impression taking is especially designed to offset the viscid secretions. In this third class the flabby tissue may be evenly distributed over the entire surface to be covered with the base-plate, or it may be interspersed with hard tissue. Each condition will require a suitable impression.

Technic for Flabby Gum.—When the soft tissues are thick and evenly laid over the surface to be covered with the base-plate, a suitable-size, flat, oval-floor tray is selected, a roll of soft wax, the size of a lead-pencil, is placed upon the maxillary surface at the periphery of the tray, carried into the mouth, and placed firmly into place. While holding the tray firmly with a finger or two upon the center of the vault of the tray, the lip and cheeks are drawn downward and then externally pressed inward. The tray is then removed from the mouth, and the wax cooled. The space formed by the peripheral wax is filled with a soft mix of plaster. The technic of inserting the tray into the oral cavity and adjusting it is the same as previously described. The object sought is to have the soft tissues evenly compressed throughout the entire periphery of the base-plate and no compression over the inclosed portion. Fig. 35 shows a flat tray with peripheral wax.

Technic for Interspersed Hard and Soft Tissues.—As an axiom, it may be stated that increased pressure should not be placed upon either hard or soft tissue in the vault of the mouth except upon the palatal border; or, conversely stated, increased pressure should be made upon the palatal border, the alveolar ridge, and external to the alveolar ridge. The most common occurrence of the condition under consideration is a spongy vault with the alveolar ridge moderately hard upon either side as far forward as the location of the cuspids, and a flabby condition from cuspid to cuspid location.

Fig. 36 is a tray reinforced for such a case. The palatal border wax should extend forward to rest upon the malar process, only when it is covered with an excessive amount of soft tissue. The anterior portion of the tray should have a sufficient quantity of wax to cover all of the flabby gum tissue. The metal flange should be cut low and replaced with a thin piece of yellow wax. As in all cases, the soft wax is adjusted to the mouth. The tray is filled (avoid much excess) with a moderately thin plaster, inserted, and adjusted

FIG. 36

as previously described. Notice! Hard—not firm, but hard, continued—pressure is made upon the center of the vault of the tray. The lip and cheeks are *drawn downward* and *compressed externally* as in other cases. The pressure upon the tray is continued until the plaster has set. By this means a firm foundation will be established for the artificial denture.

Rarely will the buccal portion of the gum tissue be excessively flabby, but when it is the denture must have a bearing

beyond the soft flabby tissue if possible; and the buccal flange of the base-plate must extend as far outward as the free action of the buccinator muscle will permit. The object sought is to have the force of mastication distributed over as broad a surface as possible, and thus prevent undue pressure upon the palatal processes of the maxilla.

So far there has been discussed but one method, with its modifications, for taking full upper impressions. Plaster of Paris with a suitably prepared tray is the best material the dental profession of today possesses to meet the requirements of all cases. The one serious objection to plaster of Paris is that there is no practical test for the perfection of the impression. Dependence must be placed upon knowledge and skill; knowledge of the requirements of the case and skill in applying the knowledge. Should a plaster impression be replaced in the mouth, strong adhesion may be induced by its capacity to absorb the moisture upon the mucous membrane; but this will take place equally as well or better with a poorly adapted impression. An inspection of the impression may show a perfect imprint of the mucous membrane, but it does not differentiate between proper compression and improper distortion of the soft tissues. So knowledge and applied knowledge (skill) must be arbiters of the perfection of the impression. The artificial denture made from an impression may be positive evidence that the impression was perfect, but it is no evidence that it was not good.

Mention has been made of ropy or viscid secretions as an adverse factor associated with flat and more or less flabby vaults. The author is of the opinion that these conditions may be best met by the use of modelling compound. Also, he believes that no first impression should be taken with this material, because the line of demarcation where plaster ceases to be the best material and modelling compound demanded is so obscure that preference should always be given plaster of Paris. Modelling compound is far more difficult to handle (properly) than plaster of Paris. The latter material is more scientific and requires less skill than the former, especially if the case is a difficult one. This last statement is contrary to the generally accepted opinion, but

nevertheless it is true. The reasons for these statements will develop as the methods for the use of the compound are described.

IMPRESSIONS FOR ENLARGED RAPHÉ.

Technic.—The impression for this class is the same as for the normal class, except in the palatal reinforcement wax.

The object sought with these enlarged raphé is to have contact without pressure. The palatal reinforcement wax is adjusted as in all cases, when a layer of the wax covering the hard raphé is removed to the extent of $\frac{1}{16}$ of an inch in thickness; and the impression *and denture* must extend backward beyond the hard area, at least $\frac{1}{8}$ inch, and better, if there is $\frac{1}{4}$ inch for bearing surface. If there is much thickness of soft tissue upon each side of the hard raphé, a little additional soft wax may be placed over the cold reinforcement wax covering the soft tissue of the vault, and readjusted to the mouth with moderately firm pressure. Should the anterior portion of the raphé touch the tray, it must be relieved by depressing the tray (use horn or wooden mallet). The tray is filled with soft plaster and placed in the mouth and pressure applied back of the middle of the vault of the tray. This will compress the soft tissue upon each side of the hard raphé. As a space has been made in the wax covering of the hard raphé, some of the soft plaster will be forced backward. This objectionable feature may be controlled by having the patient's head inclined forward.

FULL LOWER IMPRESSIONS.

Classification	High ridges	Broad.
		Thin.
	Flat ridges	Broad buccal and lingual flanges.
		Narrow buccal and broad lingual flanges.
		Narrow lingual and broad buccal flanges.
		Both flanges narrow.

Technic.—In all lower impressions the controlling factor for the width of the flanges of the tray will be the insertion of the mylohyoid and the frenum linguæ on the lingual and the buccinator and labial muscles on the outer flange. A rule may be established that in no case shall the flange impinge upon a muscle.

High Ridge.—The only difference required for an impression for a broad or thin high ridge is in the wax reinforcement. With a broad ridge the reinforcement is upon the lingual flange only, while for a thin ridge both flanges should be reinforced. Fig. 37 illustrates a tray reinforced for a broad ridge, and Fig. 38 is prepared for a thin ridge.

Broad Ridge.—The operator should assume same position in respect to patient as mentioned in technic for upper impressions. After the flanges of the tray have been adjusted for a broad high ridge, a roll of soft wax, about the size of a lead-pencil, is placed upon the warmed mandibular surface of the lingual flange, and inserted in the mouth in the same manner as described on page 88, except that the floor of the tray is upward. As the wax is pressed against the lingual wall of the process the patient is requested to raise the tongue momentarily to the roof of the mouth. The tray is removed, wax chilled, and excess cut away. It is then filled with soft mixed plaster and quickly adjusted in the mouth, by first adjusting the left side, and then the right side. As the left side of the tray is settled into position the finger used to distend the left angle of the mouth is carried backward, and with the thumb grasps the cheek, drawing it downward and outward, thus preventing a portion of soft tissue being entrapped under the buccal flange of the tray. The finger is then moved forward to the buccal frenum, which is distended, and then the labial frenum is drawn into place. The finger is removed and the left thumb inserted across the mouth as far backward as the angle of the mouth will permit. The fingers will be under the mandible, and the thumb resting upon both arms of the tray. As the right side of the tray is being forced into position, the right index finger having been carried into the mouth, the right cheek is grasped and drawn out of the way of the buccal flange. Pressure is then

Fig. 37

Fig. 38

made over the border of the buccal and labial flanges with the fingers of the right hand. The thumb of the left hand is then placed upon the left side of the tray a little back of the angle of the mouth, while the right thumb is placed in a like position upon the right arm of the tray. As the fingers of both hands are pressing firmly against the under margin of the mandible the tray is held as in a vise. The patient is requested to raise the tongue firmly against the roof of the mouth, after which it may rest easily on the floor of the mouth. The tray should be held firmly until the plaster is set, when it is removed by grasping the handle with the right hand and distending the left cheek and lip with the index finger of the left hand.

It is necessary to get the tray and tissues adjusted before crystallization of the plaster has much progressed; therefore it is desirable to have a definite system, so that no time may be lost. Every movement should be positive, but gently executed.

Thin Ridge.—The flanges of the tray having been adjusted, a roll of soft wax is placed upon each flange and pressed into position. The wax cooled and trimmed is shown in Fig. 38. The object sought in this impression is to have even compression upon the periphery of the base-plate while there is but slight pressure upon the crest of the ridge. This should relieve one source of pain in artificial dentures; that is, undue pressure upon the mucous tissue drawn over a sharp crest of bone. If the thin ridge of gum has become pendulous, from excessive resorption of the process, it is well also to have it relieved of pressure. The plaster should not be mixed stiff enough to make pressure in any impression; the pressure should be made by the reinforcement wax. The plaster is designed for close adaptation.

Flat Ridges.—For these cases a series of oval-floor trays should be prepared as the emergency demands. Two or three trays of different sizes prepared for this class of cases will probably be sufficient. The tray is prepared by cutting off the handle and about one-half of the flanges. They should be so trimmed that when they are placed in the mouth the muscles of the mandible will not much disturb them.

First Subclass.—(See classification for full lower impressions.) Either the regular oval-floor tray with the flanges bent outward, or one of the specially prepared trays should be chosen, as best fits the case.

Second Subclass.—A regular tray with the lingual flanges bent inward and the buccal flanges rolled outward and upward will probably best meet the requirements.

Third and Fourth Subclasses will require the specially prepared tray.

The impressions of all of the flat-ridge cases should be taken first in wax, or, in modelling compound. If the patient can be prevailed upon to aid, the margins should be muscle

Fig. 39

trimmed. If the patient has not sufficient control of the muscles of the face so he can assist, the operator must hold the tray with the thumb of one hand so that the other hand is free to work the tissues. The right hand should hold the tray while working the tissues upon the left side, and *vice versa*. The patient can at least be prevailed upon to forcefully raise the tongue. This wax or modelling compound impression should be considered only as a reinforced tray. Grooves should be cut in the mandibular surface of the reinforcement when it is covered with soft plaster and inserted in the mouth. The buccal tissues must be removed from under the buccal flanges of the tray as directed on page 97.

The impression should not be removed from the mouth until the plaster is thoroughly hard. As the impression is surrounded by saliva, there will be little danger of excessive adhesion.

Fig. 39 exhibits full upper and lower impressions of the broad type. The lower has the lingual flange reinforced and the upper has the palatal reinforcement.

PARTIAL UPPER IMPRESSIONS.

Classification
- Anterior teeth lost.
- Posterior teeth lost.
- Teeth and spaces alternating.

Fig. 40

Anterior Teeth Lost.—For all partial cases a flat-floor tray of suitable size should be chosen. If three or more teeth are lost the vault reinforcement wax of Fig. 40 should be extended forward to nearly fill the space occupied by the

lost teeth. There should be about $\frac{1}{8}$ of an inch of space between the wax and the remaining teeth, also between the wax and gum (Fig. 40). Judgment should be exercised in the quantity of plaster used, thus avoiding much excess. As partial plaster impressions are almost certain to be broken while removing from the mouth, a small tray (lacquer or metal) and tweezers should be upon the bracket table, so that the pieces may be placed in order as they are removed from

Fig. 41

the mouth. Figs. 48-52 illustrate such an arrangement. Fig. 41 is a tray properly filled with plaster for taking an impression where the four upper incisors are missing. The plaster should be mixed just stiff enough so it will not run when placed in the tray. This implies that, because of its stiffness, the time of setting is shortened, and that it must be quickly adjusted. In such a partial case the lingual aspect, and possibly the occlusal surface of the teeth, is desired.

With the loss of any increasing number of teeth backward, the reinforcement wax is extended; the technic is the same as just described. Fig. 42 illustrates the wax reinforcement for the lost ten anterior teeth.

Posterior Teeth Lost.—This class implies that the remaining anterior teeth are in phalanx and that there are distally no isolated teeth. In such cases a flat-floor tray should have the

Fig. 42

reinforcement wax as in Fig. 43. This prepared tray is for a case with the teeth lost distal to the first bicuspids. Fig. 44 has the plaster suitably placed.

Teeth and Spaces Alternating.—Fig. 45 is a tray suitably reinforced. In all partial cases, except where wax contact is desired, there should be a space for plaster over the wax reinforcement of $\frac{1}{8}$ of an inch or little more. The alternating

Fig. 43

Fig. 44

spaces may be dovetail-shaped. In such cases cores should be made of wax to fill them. Fig. 46 is a plaster cast showing a space between the second bicuspid and second molar

Fig 45

Fig. 46

requiring a core. In the illustration the core is attached to the upper surface of the cast. The core is made by filling the space (without drying the teeth) full of soft wax. Most of the excess wax may be trimmed away in the mouth. The wax is made cold and removed through the wider aspect of the space. In this instance it should be pushed inward. The wax is then thoroughly chilled and trimmed pyramid-shape, with the base resting upon the gum. After it has been cooled and trimmed (pyramid-shape) so the plaster will draw from it, it is secured in place by slightly pinching

Fig. 47

the occlusal end. If there are large spaces, as for the incisor teeth, the tray should be reinforced as shown in Fig. 46. After the impression has been removed from the mouth, the wax core is carefully removed *and replaced in the impression.*

Isolated Teeth Methods.—Fig. 47 shows a cast with the two cuspids and the left second bicuspid remaining. The teeth were short and firmly attached, so there was no danger of their extraction in the impression. In this case all the preparation necessary was the reinforcement of the tray, as in Fig. 43. However, if the teeth had been long and bell-shaped, and loose, it would then have been necessary to have thor-

oughly dried the teeth (one at a time), and to have molded a little soft wax about the neck of each tooth as it was dried. The plaster impression would either draw away from the wax, when it should have been replaced in the impression, or the wax would have remained in the impression. Had the teeth dragged through the wax no harm would have been done other than a slight distortion of the wax.

Fig. 48

Fig. 48 is the impression taken for the cast shown in Fig. 47. Some of the reinforcement wax is shown; also the fragments are placed in order about the main portion of the impression. Fig. 49 shows the assembled pieces luted together with wax.

Detachable Tray Method.—In this method no wax reinforcement should be used, except as in Fig. 45; and this

should be so trimmed that there are no undercuts. The maxillary surface of the tray and reinforcement wax are smeared with a thin layer of vaselin. This will permit the tray to part from the hardened plaster, which may be removed in sections after the manner used by orthodontists. The maxillary surface of the tray should be smooth, and in no degree dovetail-shaped. If this method is to be used.

Fig. 49

the operator should first carefully observe the teeth and vacancies, and devise a scheme for notching and breaking the plaster in sections. The notching and breaking are done with a stout knife, which must be well guarded so the patient may not be injured. As the pieces are removed from the mouth they are placed in order on the lacquer tray. The impression tray may be removed from the mouth and notches cut in the plaster, but no attempt should be made

to break the plaster away from the teeth until it will make a clean break, that is, not crush. The inexperienced student should be very cautious of choosing this method, because of the danger from the knife. However, the tray may part from an impression unexpectedly, when it becomes necessary to notch and remove the impression in sections.

Fig. 50

PARTIAL LOWER IMPRESSIONS.

Classification.—The classification used for partial upper impressions is applicable for lower ones. The wax reinforcements are the same except that there is no vault, and in place of a palatal-margin reinforcement a lingual-flange reinforcement is required. Rarely should any lower impression (either partial or full) be taken without the lingual flange being reinforced. This is necessary to control the folds of the soft tissues and the submaxillary and sublingual glands that are occasionally very troublesome. In all cases the mylohyoid muscle influences the loosely attached mucous membrane for a long distance above the origin of the muscle, and draws it inward and upward. As a result, if the lingual-

FIG. 51

FIG. 52

Fig. 53

Fig. 54

flange compression wax is not used the lingual flange of the completed artificial denture will not lie close to the mandible. This is often a source of annoyance to the patient.

Fig. 50 shows a flat-floor lower tray with reinforcement. Fig. 51, with the plaster in place ready for insertion. Fig. 52 shows the impression with the fragments and a core. Fig. 53 is the assembled impression. Fig. 54 is a Weiss tray

Fig. 55

(a modification of the type shown in Fig. 23) and fragments. This tray requires the lingual-flange reinforcement only. Fig. 55 is the assembled impression.

MODELLING COMPOUND FOR IMPRESSIONS.

As Ordinarily Used.—A tray is selected, and the flanges adjusted as for a plaster impression. No reinforcement

is required. A portion or a whole cake of modelling compound, as the judgment dictates, is softened in water (see page 68) and placed in the warmed tray. In manipulating the compound all folds should be kept on the under portion, so the surface taking the imprint may be smooth and continuous. The side of the index finger may be imbedded first upon one side and then upon the other, so as to form a groove for the alveolar process. The surface is then given an extra softening by passing over a smokeless flame. The compound filled tray is carried into the mouth and forced into place after the manner described for plaster (page 88). The lip and cheeks are manipulated in the same manner as for plaster. The compound is left in the mouth until it has hardened. Hardening may be expedited by using cold water. A small piece of cloth (an aseptic napkin) is saturated with cold water and held against the lingual surface of the tray. Some of the cold water may be thrown under the lip with a syringe. When the compound has become hard it is removed in the same manner as a plaster impression, except in no case will it be necessary to use a spray of water as an aid to loosen it.

Advantages and Disadvantages.—The advantages of compound are claimed to be that it takes a sharp impression, does not break upon removal, and compresses the soft tissues. The first two claims are true, but the second claim of superiority should be classed as a disadvantage, for a material that does not break must bend or drag when taken from an undercut or dovetail-shaped space. The third advantage claimed is very questionable. As ordinarily used the compression is not under the control of the operator. The material is usually forced so far backward upon the soft palate as to produce contraction of that organ, and cause depression in place of compression at the palatal border of the impression. The soft tissues upon the labial and buccal surfaces are usually distorted. Because of this distortion many operators find it expedient and useful to use a "bead" upon the maxillary surface of labial and buccal flanges of an artificial denture. Following a properly taken impression, a bead in this position should be unbear-

able. One skilled in the use of any material may produce excellent results, but that is not evidence that it is scientific or the best. The confusion existing in the profession regarding the various impression materials, is due to a lack of comprehension of the underlying principles.

Technic for Modelling Compound Impression.—A suitable-sized oval-floor tray having been selected, the handle and most of the labial and buccal flanges are cut away. If an unsatisfactory base-plate has been constructed it may be converted into an admirable tray by cutting away at least one-half of the width of the flanges. About one-third of a cake of compound is softened, dried, and spread over the warmed maxillary surface of the prepared tray. This is carried into the mouth and hard, continued pressure applied so as to compress all the tissues over the vault and ridges; at the same time the patient should comply with the instruction previously given and draw the lip and cheeks downward by hard, vigorous muscular action. This, Dr. J. W. Greene, in the Greene brothers' method of impression, calls muscle trimming. The best position in which the operator may stand while taking this form of impression is directly back of the patient. The partially taken impression is removed from the mouth, thoroughly chilled, and any excess removed. The peripheral labial and buccal borders are warmed over a small, weak Bunsen flame and quickly returned to place in the mouth. It is securely held in place with one hand, and, while the patient is muscle trimming, the operator makes interrupted compression over the lip and cheeks with the disengaged hand. It may be necessary to rewarm and muscle trim several times, or an addition of soft dry compound may be needed upon portions of the rim of the impressions. This addition may be made by "tracing on" with a stick of compound. When the operator is satisfied that the rim of the impression is perfectly adapted backward to the anterior border of the malar processes, the impression is thoroughly chilled, dried, and a small roll of soft modelling compound placed along the palatal border, upon the maxillary surface, and extended around the tuberosities to the malar processes. This addition is made quite soft in the small Bunsen flame,

carried into the mouth, and quickly forced into place, removed, and dried. If it has not been sufficiently compressed, it is again softened and pressed in the mouth. The impression may now be considered complete. It is placed in cold water until thoroughly cold, and without drying it is replaced in the mouth and very firm pressure made upon the lingual surface of the tray while the lip and cheeks are lifted and drawn into position over the rim of the impression. The fingers are removed from the mouth and the patient requested to remove the impression. If the impression has been properly manipulated it may be impossible for an inexperienced patient to remove it. The patient should be instructed to dislodge it by working the lip and cheeks and closing their lower teeth upon it in every way possible. Should it prove to be insecure at any place it should be corrected, either by softening and muscle trimming, or by adding soft compound.

Rationale.—The reason for this excessively strong adhesion is apparent. By this method of taking the impression there is absolute contact of the entire periphery of the impression except over the malar (zygomatic) processes, where there is an automatic valve in the soft tissues of the cheek. As the peripheral border is forced into the soft tissues and either cheek raised, the moisture and air occupying the free space within the impression is forced out over the malar process; then, as the cheek is lowered, it acts as a valve and prevents ingress of air. As the pressure is relieved from the lingual surface of the tray, the resilience of the soft tissues under the periphery of the impression causes a thin vacuum space over nearly the whole maxillary surface.[1]

This explanation of the strong retention of the impression suggests also how to remove the impression, which is done by raising the cheek and pulling downward upon the periphery of the impression at the malar process. As air is admitted the impression is loosened.

The durability of such strong adhesion and its sequence are not relevant at this time, but will be discussed in the chapter on Retention.

[1] This description is but a slight modification of the Greene brothers' method.

Fig. 56 is a modelling compound impression taken in an inefficient cast aluminum base-plate. A close inspection will show the muscle trimming, lines showing addition to the anterior flange, and a well-marked line showing the compressing portion added to the palatal border and tuberosities. That the student may appreciate the painstaking exactness such an impression requires, it is well to state that this individual impression was adjusted to the mouth probably fifteen times, but the final result was good.

Fig. 56

THE GREENE–SUPPLEE METHODS FOR MODELLING COMPOUND IMPRESSIONS.

Mr. S. G. Supplee, of New York City, has formulated and introduced a system for taking impressions, based upon the methods taught by the late Dr. J. W. Greene, which has both merit and fallacies.

It would not be time well spent to try and differentiate the methods employed so as to give credit to each man, nor, is it at all likely that either man has made a new discovery; but great credit is due both of them for creating a new appreciation of old though illy understood truths. They have both done meritorious work in developing an improved technic and apparatus for convenience. Unfortunately they were both

imbued with the commercial spirit and devoted to creating something to sell rather than in discovering the underlying principles. Nor could more be expected, for neither of them was grounded in anatomy and physics, but both have given freely of their inspiration. It remains for the profession to convert their veiled teachings into concrete and classified knowledge. These men have done a great work in awaking the profession to the possibilities of impression taking in this dawn of a new era in dental prosthesis.

"Muscle trimming" and "closed-mouth methods" are fallacies. The results obtained were due to clever manipulation notwithstanding the fallacious methods used. The secret of the success of the methods taught by these men was entirely due to the palatal adaptation and extension. The two methods will be discussed in the chapter on Retention.

Requirements for impression taking with modelling compound:

1. Fine quality low heat compound.
2. A large and small Bunsen flame.
3. Hot water of a definite temperature.
4. Cold water or compressed air.
5. Trays to suit the fancy of the operator.
6. A technic.

The quality of compound should be carefully selected for fineness, smoothness, and low heat properties. These properties are easily ruined by overheating and repeated use which is also unsanitary.

The ordinary Bunsen flame used in the laboratory will suffice for the large, but a small weak gas flame or an alcohol lamp is necessary for the small flame.

Fig. 57 shows Mr. Supplee's hot-water heater for working modelling compound. It is excellent for its purpose. The upper stratum of water should be kept at 160° to 170° F., while the water at the bottom of the pan will be approximately 20 degrees cooler. The bottom keeps the stock compound in condition for first adaptation, the upper stratum is the suitable temperature for immersion of compound after heating in the Bunsen flame and just before inserting in the mouth.

Cold water or compressed air is an absolute necessity for setting the compound just before removing from the mouth.

The essential qualities for the trays are, low flanges and ease of adaptation. Each of these men has provided a patented set, yes sets, that expressed their conception at the time of invention, for the necessary attributes for trays. Others, notably Dr. W. A. Giffin, prefer to swage a tray, for each case, of English dental tin. However, any tray will suffice that will support the compound and permit manipulation of the periphery of the impression.

Fig. 57

The technic varies with the individuality of the demonstrator. The writer has never seen a demonstrator of strong personality that exactly followed his instructor. He usually insists that certain modifications are essential for "perfection." However, the underlying principles of all the various methods may be summed up in three statements:

1. Areal contact.
2. Peripheral bearing with freedom of muscle action.
3. Extension for retention.

On page 120 is a general description for the technic of the various methods.

PARTIAL CASES.—Impressions for partial cases without undercuts are taken the same as though no teeth were present. All partial cases with dovetailed spaces may be taken in a tray with little or no labial and buccal flanges. First take the impression of the lingual and occlusal surfaces of teeth and the required portion of the gum only. This portion may be removed, trimmed and readjusted as many times as necessary. The edentulous spaces are taken one-half through. With this portion of the impression held in place an impression is taken of the labial and buccal surfaces. This second portion of the impression necessarily overlaps the first portion, so that the two portions may be accurately adjusted out of the mouth. The labial and buccal compound may be supported by a strip of sheet tin or aluminum.

THE HALL METHOD FOR IMPRESSIONS.

Dr. Rupert E. Hall,[1] of Houston, Texas, has devised a method for plaster impressions designed to utilize the modelling compound principles advocated by the late Dr. J. W. Greene. He uses a specially prepared hard black tray compound (The S. S. White Dental Mfg. Co., maker) for making a suitable tray for each case, and a very thin mix of impression plaster, which is built up in layers as required.

The Hall method is especially adapted to difficult full cases. It is not recommended for partial cases. This plaster method is superior to the modelling compound methods in that the soft mix of plaster is far more delicate and adaptable than the compound, and when set it is not distorted by subsequent treatment.

With a few minor changes the following description is in the words of Dr. Hall and as such is commended for careful consideration.

The Individual Tray.—The first, or basal essential in the taking of a perfect impression is a tray suited to the case; in other words, a tray that fits. You see this in the changes

[1] Now of Chicago.

the prosthetist makes in his metal trays—bending and cutting them to secure better adaptation. From the very nature of the work a special tray is necessary to get perfect results.

The black impression-tray compound was devised for the particular purpose of making these individual trays quickly and economically. It is somewhat of the nature of a modelling composition, but with differences that adapt it specially to the making of trays. It is jet black in color to make it readily distinguishable; has a high melting-point to assure ample rigidity when set or hardened and trimmed to a thin edge; and is readily cut as may be desirable in shaping it.

The Impression Material.—The second essential to the making of a perfect impression is a material of a consistence that will yield to the delicate soft tissues of the mouth when it is applied, without offering the slightest resistance; and then set or harden quickly into a rigid non-elastic mass bearing the perfect impress of every detail of the surface with which it has been brought into contact. Thin-mixed plaster—so thin that it flows—is the ideal material for taking impressions. The superiority of plaster as an impression material has always been recognized. The method described below shows the way to utilize it to get the ideal results that have been the aim and the despair of prosthetists from time immemorial.

Making a Tray.—It is necessary in employing the black impression-tray compound to have a few regular metal trays of suitable forms and sizes. (S. S. White britannia-metal upper trays Nos. 1, 2 and 3, and lower trays Nos. 1, 2, 3, 18 and 19, are most desirable for this method. In taking lower impressions, the Nos. 18 and 19 should be employed whenever the conformation of the tissue permits their use.) Take a metal tray of the proper shape for the case, but somewhat larger than you would ordinarily use. Fill it with the compound, softening in hot water—a higher heat will be required than in softening ordinary modelling composition. Pass it over a Bunsen or alcohol flame to soften and remove inequalities in the surface and give it a glaze. Plunge quickly into hot water to wet the surface and prevent sticking to the tissues, and as soon as it cools to a bearable degree insert in the mouth and secure an impression in the regular way. In

a short time it can be removed from the mouth and placed in cold water to harden.

Remove the compound impression from the metal tray, trim away the compound until you have a thin tray form; the inner surface of the periphery should also be trimmed to allow plenty of room for the plaster to escape freely to prevent compression of the tissues. Do not trim the tray too short, as otherwise the plaster when applied in the tray may not be carried to place; or if it is, it will break off because of the unsupported overhang. If you should happen to trim the tray too short, or need to add to it, the difficulty can be reme-

Fig. 58.—Palatal view of finished individual tray after trimming and scoring.

died by fusing more of the compound to the form wherever desired, inserting in the mouth while soft, and allowing the tissues of the mouth to properly shape the tray outline, which can then be cut down a little to allow for the plaster. Finally, score the maxillary surface to give the plaster a firm hold. (Fig. 58.)

You now have a tray that perfectly conforms to and fits the individual case, with no bulky projections or protruding edges to impinge upon and distort the soft tissues or push them from their normal positions.

Plaster and Its Manipulation.—Mix clean, fine, quick-setting impression plaster very thin. The plaster should be sifted

thoroughly at the time it is used, to be sure that it is freed from any lumps caused by dehydration, as commonly found in plaster. French's Impression Plaster (cans or buckets only) should be used; *never bulk plaster*.

Mixing the plaster homogeneously of the proper consistence is difficult and extremely uncertain by hit-or-miss methods, but by following the plan here outlined the homogeneity and consistence of the mix can be perfectly controlled

Fig. 59.—Dipper sieve for sifting plaster. It is used by holding it over the plaster bowl, and tapping the rim with the spatula, which assures the plaster reaching the water in a finely divided condition, free from lumps and débris.

and standardized: Place the proper quantity of plaster in a dipper sieve of a size that will work inside the plaster bowl (Fig. 59); provide an excess of water in the bowl and sift the plaster into the water as fast as it will sink. When sufficient plaster has dropped to the bottom of the bowl pour off the free water—down to the plaster—and you have the correct proportions of plaster and water to make the proper mix.

Little spatulating is necessary—just enough to assure a uniform consistence. You will then have a plaster mix of cream-like character much thinner than is ordinarily used in impression taking—thin enough, in fact, to flow readily around and over the soft tissues without disturbing them.

Because of this thinness it is obvious that the plaster must set as quickly as possible after it is inserted in the mouth and flowed about the tissues; as otherwise the influx of the secretions will wash away the plaster before crystallization, thus preventing the close contact with the tissue that is necessary. No fixed rule for the setting time can be made. Grades of plaster vary in setting time; climatic conditions, room temperatures, the temperature of the water, individually or in combination, are all factors that affect the mixing and manipulation of plaster. However, as the best results demand quick setting the plaster should be so mixed and manipulated with regard to varying conditions as to effect the result.

Upper Impressions.—The taking of upper impressions requires a series of applications of plaster, the first of which is only to determine the approximate position of the delicate tissues and muscles and to indicate points where the tray must be trimmed away.

Have the patient sit erect in a normal position. This closes the fauces and prevents the plaster passing down the throat. Fill the tray, insert in the mouth and proceed with a wiggling motion to carry the tray to place, being careful to use no more force than is absolutely necessary, while the patient slowly closes the mouth.

To expedite and insure a safe removal of the impression have the patient close the lips and fill the mouth with air, distending the cheeks and lips, which breaks the adhesion (Fig. 60). All interfering parts of the tray showing compression of the tissues and muscles are cut away and all excess plaster removed. A second application of plaster or as many as are necessary to correct any imperfections are made until a perfect counter-reproduction of the tissues or impression is obtained. The average case requires two applications of plaster.

This method properly carried out will produce a perfect impression from which a plate can be made that, because of its

accurate adaptation, dispenses with the need of air-chambers, suction devices and the like (Fig. 61).

FIG. 60.—First trial plaster impression. Note imperfections that make a second application of plaster necessary.

FIG. 61.—Second trial, producing a perfect plaster impression, bringing out every detail of the palatal surface and peripheral margin with normal muscle relations.

For Lower Impressions.—In taking a lower impression we have the help of gravity in carrying the plaster to place.

Because of this only one mix of plaster and one trial are necessary instead of two or three; but to carry out the work correctly and to get the perfect result possible with this method it is important that the tray fit as accurately as possible; that is, all long interfering edges must be relieved. The most delicate or gentle pressure possible should be employed in bringing the plaster into contact at every point without compressing the soft parts. A small handle (that will not interfere with the lip) made from the tray compound or wax attached to the tray with a hot spatula greatly facilitates the manipulation of the tray. The tray should never be forced against the tissues; but after being inserted properly should be gently "wiggled" to allow the plaster to drop in place.

After the tray carrying the plaster has been inserted, have the patient raise the tongue as high as may be, pointing it forward; then after the tray is adjusted, drop the tongue to rest. This procedure allows the thin plaster to run into every space, extending under the tongue wherever there is room. Do not trim this off, but preserve it carefully, remembering that wherever the plaster runs rubber may be substituted, because it can be depended upon that plaster used as here described—very thin—will not compress or displace the tissues. The flanges (when extending under the tongue) so provided give the plate a larger bearing surface, assure the help of the tongue in holding it in place, and diminish the opportunities for food to get under the denture.

This method properly carried out may be depended upon to produce lower dentures which, because of their perfect adaptation, will have suction, a condition heretofore unknown except in rare cases; proving beyond doubt the accuracy of the method and its superiority over any other procedure yet devised.

Relieving the Hard Spots.—After the impressions are made, try the upper in the mouth and test for fit. Put pressure upon one side and the other, as would be exerted in masticating upon the finished denture. If it rocks, you have evidence of a hard area or areas in the palate. Remove the impression, locate the hard areas, outline them upon the maxillary side,

cut away (with sandpaper—the knife will cause chipping of the layers) the plaster at the places indicated until you have relieved all pressure or contact between it and the hard areas of the palate, and you can no longer rock and dislodge the impression. Sometimes hard areas will be found which are not extensive enough to noticeably affect the fit. They should always be outlined and relieved upon the impression, or upon the cast with tinfoil at the time of vulcanization, because after the denture is worn for a time it may settle and ultimately bear upon the hard areas and develop rocking.

The work is done under normal temperatures—there is no distortion through engorgement of the tissues by a high heat. The plaster because of its thinness flows naturally into undercuts and spaces, assuring a perfect reproduction of all parts—soft and hard—in repose, and all surplus escapes.

IMPRESSION APHORISMS.

1. An impression constitutes the foundation upon which the success of an artificial denture depends.

2. A suitable impression can be obtained only by studying the case and devising a definite scheme of procedure.

3. A stock tray should be adapted to the individual case, by bending, trimming, and the addition of reinforcement.

4. Compression should be made through a properly formed tray by means of reinforcements. No impression material has discriminating power, hence cannot be depended upon to make suitable compression.

5. Plaster of Paris is the best impression material because of its plasticity, adaptability, rigidity, friability, and controllability.

6. Modelling compound is valuable in specific cases because of its rigidity and workableness. It is very delusive because of its toughness.

7. An impression material is of value only as it is intelligently and skilfully worked.

8. Plaster of Paris is aseptic because it can be used but once. Modelling compound is dangerous because it may

be used repeatedly and cannot be sterilized by heat without destroying its working properties.

9. Small simple impressions may be taken either in plaster of Paris, modelling compound, or wax. The accuracy will be in the order named.

10. The more difficult the case the more essential is the plaster-of-Paris impression.

CHAPTER III

CASTS.

Definition.—A cast is a reproduction in plaster of Paris, its compounds, or some plastic material, of an object or part, made from an impression or mold. Casts are used to give their negative likeness to an artificial denture.

Unfortunately there is much confusion in dental nomenclature in the use of the term cast and model. There is no authority outside of the dental profession for calling a cast a model, as is too commonly done in vulcanite nomenclature; and such indifference in the use of technical terms can only lower one in the estimation of learned people. "Cast" is from *kasta,* throw, and is used in the sense of throwing, pouring, or forming a plastic material in a mold or impression. The term "cast" is applied to objects made of plaster of Paris, wax, and similar substances, while the term casting is usually applied to metallic objects formed in molds.

Model is from *modus*, measure, and is defined as an object representing accurately something to be made or already existing; a material pattern of natural, heroic, or diminutive size. Model is differentiated from pattern in that a pattern is usually flat, while a model has material contour.

In sculpture the model is the plaster or clay original of the work to be executed in stone or metal; a person who does duty as a copy for painters or sculptors.

A sculptor may idealize his living model; but his workman must exactly copy the clay model made for him.

Even the dressmaking trade uses the term model correctly. They use a model to give its form to the human body, also to the external surface of the garment. It is only an incident that the garment is made over the model, for the object sought is to give form to the outer surface of the garment.

The photographer speaks of his negative, not of his pattern or model. If he uses the term model, he uses it correctly

and applies it to his subject, not to the intermediate, the negative.

A dentist uses casts, castings, and models, and he should, if he is a member of a learned profession, differentiate and use his terms intelligently and correctly. A cast is anything formed, while in a plastic state, in a mold or impression; casting (noun) is a term applied to metal casts; and model is an object to be copied, but it is a positive, not a negative copy. Of all the arts, sciences, and crafts, dentistry alone uses the term in both a positive and negative sense. Such use is entirely inexcusable, because it leads to confusion of thought; besides there is no dearth of correct terms in common use.

It is interesting to note the origin of this use of the term *model* in dentistry. At the time of the introduction of vulcanite, during the fifties of the last century, plaster models were in constant use for constructing dies for metal baseplates. As vulcanite work is constructed upon the plaster form in place of a metal form, it was only natural that the familiar term *model* should be retained for the new use. Unfortunately, the teachers and writers of text-books at the time of the introduction of vulcanite did not give sufficient thought to the philology of the glossary required for the new art; hence some of the terms that have come down, even to this day, are not scientific.

A plaster model is never used in vulcanite work as ordinarily constructed. Plaster casts are used. A plaster cast gives its negative likeness only to the inner surface of a vulcanite denture, therefore cannot correctly be called a model. Orthodontists make plaster casts of cases as records of progress and completion. A plaster cast becomes a model only when it is used for duplication. The patient's jaws are the models, not their plaster reproduction.

Uses for Casts.—There are two general uses for casts in dentistry: (1) as a form over which something is constructed; (2) as a model or copy.

Materials for Casts.—The material for casts must be chosen with regard to the process to be employed. The materials may be classified as: (1) plaster of Paris; (2)

Spence plaster compound; (3) plaster compounds known as "investment compounds;" (4) wax and its compounds as models for metal castings; (5) new compounds.

Plaster for Casts.—From the study of the expansion, contraction, and compressibility of plaster, it is obvious that its use is limited, and that dental operations often require casts that are less subject to change by heat and pressure. While some operators are accustomed to use building plasters for certain purposes, it is better to select from the various compounds of plaster for dental use the one designed for the work at hand. Failures and imperfections due to the use of unsuitable material may thus be avoided. For all purposes, when little heat or pressure is to be used, French's *regular dental plaster* serves an excellent purpose. This plaster is found in all well-stocked dental supply houses, and is the only plaster carried by many of them.

Spence Plaster Compound.—This is an excellent preparation of plaster of Paris, Portland cement, and chemicals to control its setting and expansion properties. This material has four times the strength of dental plaster, and the expansion is nearly at zero. As the material is now placed upon the market, if properly worked, its setting time is about the same as slow-setting dental plaster. Dr. Stewart J. Spence, of Chattanooga, Tenn., has certainly produced a very valuable material for casts which are to be subjected to moderate heat and considerable pressure. It is especially adapted for casts for vulcanite work.

It may be well at this time to consider tersely the important addition to plaster in the production of this compound. The student should not consider that any mixture of cement purchased upon the market and plaster will answer the same purpose as that bearing the name of Spence, because the Spence compound is the result of much study and experimentation.

Portland Cement.—This term was first used in 1824, and was given to a patented cement manufactured at Leeds, England. It is made by calcining and grinding a suitable mixture of lime and clay. It may be considered as a silicate of lime and alumina. There is a greater variety of cements

grouped under the general heading of Portland cement than there is of plasters under the general term of plaster.

Working Spence Plaster Compound.—The mixing of this compound with water is much more laborious than mixing plaster of Paris. The ratio of water to the compound, as now placed upon the market, is one to four. For a cast a fluidounce of water is placed in the plaster bowl, and three measured ounces of the compound are added and thoroughly spatulated with a very stiff spatula until it becomes soft and plastic, after which a half-ounce more may be thoroughly incorporated. The remaining half-ounce may be better added one-half at a time. It must be spatulated and kneaded in a bowl until the mass is putty-like in consistency, and if on continued working it becomes too soft, more of the compound should be added. When properly mixed it can be handled with the fingers and requires to be well-packed and jarred in filling the impression.

Investment Compound Casts.—This class of casts is designed to stand high heat, and must be made of a material suitable for its intended use. The supply houses furnish many of these compounds, which answer a good purpose. They consist largely of plaster of Paris for a bond to combine the material and such materials as will well withstand high heat, either singly or in combination. Of the materials used may be named: Sand (silica), clay, lime, asbestos, pulverized calcined fireclay, Portland cement, oxide of iron, pumice stone, chalk, etc.

Working Investment Compound Materials.—These materials are worked at about the consistency of plaster of Paris. Owing to the small quantity of plaster they contain, they will require much less water than pure plaster; usually one measure of water to three or four of investment compound.

Wax and Compounds.—There are a variety of preparations in the dental supply houses composed of wax, paraffin, gum, and terpene. They are formed in a mold or impression, and then the wax cast is used as a model for producing a metal casting. This material is often carved into form for a model. Such a model cannot be spoken of as a cast because it was not formed in a cavity.

Weinstein's Cast Compound.[1]—This is a calcium, barium silicate compound. It is a fine grained, hard and strong material. It is slow setting, requiring several hours for its maximum hardness. The claim is made for it that it neither expands nor shrinks.

This is a new material with which the writer has had little experience. However, any material offered to the profession by Mr. L. J. Weinstein is worthy of confidence. Nevertheless with the slight experience of the writer he cannot see that he would be benefited by substituting it for Spence Plaster Compound.

Magnesium Oxychloride.—Professor J. H. Prothero of the Northwestern University Dental School has experimented with and used this material, for casts upon which to vulcanize, for some years. His recent work, *Prosthetic Dentistry* (1916), gives a full description of the material and its use.

He says: "The powder is the heavy oxide of magnesium (commercial) and the liquid is the supersaturated solution of the chloride of magnesium (commercial). The powder can to advantage be mixed with clean sand. Sand 50 to 80 parts magnesium oxide 50 to 20 parts. It requires about twelve hours to harden."

He further says : "The principal advantages of oxychloride of magnesium for casts in vulcanite work are these: hardness, density, smoothness of surface and extremely low expansion index, less than one-fourth that of the best grades of plaster. It is sufficiently impervious to moisture and heat to maintain its form without crushing, even under high pressure.

"Rubber of any shade vulcanized in contact with oxychloride of magnesium is hard, dense, elastic, capable of taking a high polish, and on account of the density of the cast is free from nodules."

CASTS FOR ARTIFICIAL DENTURES.

The construction of plaster casts only will be further considered in this chapter, but in discussing each variety of

[1] Peeso's Crown and Bridge-work, page 120.

artificial denture the cast suitable for the work will be described.

Use of Impressions.—The preceding chapter treated of impressions and how to obtain them. This chapter treats of the use of the impression. All base plate artificial dentures are constructed over either a cast or casting, therefore for each artificial denture it is necessary to obtain a suitable impression from which a cast is obtained. This implies that there is a technic for preparing the impression and making the cast.

Preparing the Impression.—A plaster impression is often broken in removing it from the mouth. Indeed, often a plaster impression can be removed only by fracturing The property of being easily broken is one of the valuable features of plaster of Paris. This insures its removal and the accuracy of imprint when the fragments are assembled. The impression having been removed (if broken, the fragments arranged in order upon a small tray), it is permitted to dry for a few minutes (five to thirty), when, any small particles of plaster having been removed with an ox-hair brush, or a pointed instrument if necessary, the fragments are accurately readjusted in the impression tray and secured with melted wax (Figs. 48–52). If any carving is to be done upon the impression, it should be done at this stage of the procedure. However, as any carving must be done for a specific purpose, instruction as to where and how to do it can be given only in describing the work requiring such treatment. The impression is next treated with a separating fluid to facilitate the removal of the impression from the cast.

Separating Fluids—The object of the separating fluid is to so treat the surface of the impression that a perfect counterpart of the intaglio may be formed of plaster or its compounds, and the two easily separated. This is accomplished by flowing over the surface of the impression some material that will prevent adhesion of the added plaster. The desirable properties for a separating medium are as follows: (1) It should add as little substance as possible to the surface of the impression; (2) it should provide a line of demarcation with a distinct penetration of the impression; (3) it should

not cause chemical changes and injurious effects upon either the surface of the cast or the denture to be constructed over it; and (4) it should give a smooth glazed surface to the cast. There are a great variety of materials recommended and used for this purpose, but few are extensively used. They may be classified as: *Alcoholic solutions:* (*a*) shellac, (*b*) sandarac, and (*c*) other gums and terpenes added to these foundation solutions. *Aqueous solutions:* (*a*) liquid silex (silicate of soda), (*b*) soap, (*c*) borax and shellac, (*d*) ammonia or other alkaline substances and shellac. *Oils*, as sperm, lard, sweet,

Fig. 62

or vaselin; and *ethereal solutions:* (*a*) of soap and (*b*) collodion. The aniline dyes are used as coloring matter for some of these preparations. Many of these preparations are kept in stock by the supply houses, and some of them under fanciful names.

Perhaps the best and most commonly used method is to first saturate the surface of the impression with a thin alcoholic solution of shellac, and, when dry, to apply one or more coats of alcoholic solution of sandarac. These varnishes are made by dissolving one ounce of either gum in 4 ounces of alcohol. The solution is greatly facilitated by heating the

uncorked bottle, containing the gum and alcohol, in simmering water for a half-hour or until dissolved. The stock bottle should be kept well corked. If either varnish becomes too thick (by evaporation), it should be thinned with cold alcohol. The varnishes are applied to the impression with a camel-hair brush. Each coat should be permitted to dry before applying another. The shellac varnish will penetrate and give a yellowish color to the plaster of the impression for $\frac{1}{32}$ of an inch, which is a warning of the approach to the cast when cutting away the plaster impression. This may be seen in Fig. 62. If the plaster is not well colored, it should be given another coat of shellac, after which it is given one or more coats of sandarac varnish. The shellac penetrates and gives depth of color line, and the sandarac remains upon the surface and forms a glaze.

Pouring the Impression.—This is a common term used for filling the impression. The term is slightly misleading in that it implies that the plaster mix is poured into the impression. The plaster batter should be a little thicker than for an impression and a trifle too thick to pour. However, it must not be so stiff that it will not flow perfectly over the surface of the impression when jarred by rapping the tray lightly upon the table. The same rule (as to the ratio of water and plaster) is used for casts as for impressions—that is, one measure of water and two measures of regular dental plaster. If the mix seems too thin, more dry plaster should be added until the mix will stand as placed. However, it must have a pronounced glossy or watery appearance, and when this characteristic diminishes it is evidence that either too much plaster has been added or that crystallization has commenced. The surface of the impression should be thoroughly covered before this deadened appearance begins. The student should observe carefully the appearance of his plaster mixes, because the quality of the cast depends much upon the manipulation. An excessive amount of plaster added to the water or overspatulation interferes with the process of crystallization, thus causing increased expansion and reduced strength of the cast.

Technic for Filling the Impression.—The surface of the impression having been properly varnished while dry, it should then be immersed in water until bubbles cease to form, the plaster gauged, and smoothly and quickly mixed; a portion of the mix (about a teaspoonful) is placed upon the higher central portion of the impression and caused to flow into the lower portions of the intaglio by rapping the tray three or four times upon the plaster bench. Portion after portion of the mix is added and jarred into position until the intaglio of the impression is full, when the jarring ceases and the remainder of the mix is piled on and spread with the spatula until the plaster forming the cast is about one-half inch thick over the highest portion of the vault.

Shape for a Plaster Cast.—For the sake of convenience it is well to adopt such a form as will be best adapted to the various uses to which a cast may be put. A suitable form not only favors and expedites future operations, but in some cases it affords additional strength. The form affording the greatest usefulness is the truncated cone. This form is easily given to the cast by inverting the tray while the plaster is somewhat soft and gently pressing it down upon any smooth surface, as a slab of marble, glass, or metal. If the base of the cast is formed upon any rigid material, the surface should be slightly oiled, to facilitate the removal of the plaster. (A convenient arrangement is to have a 6-inch square block of wood covered with sheet zinc. This will need no oiling, for the sheet metal is flexible and will yield to pressure applied at the sides of the cast.) After the filled tray is inverted upon the smooth surface the plaster spatula should be passed about it, producing a smooth and symmetrical outline. The truncated cone form of an upper cast will not be a symmetrical truncated cone, for its base will be a parabola; and the lower one will be horseshoe-shape. Instructors are accustomed to direct that the base of a lower cast should be made solid (for strength) in place of a horseshoe-shape. It is better to sacrifice a portion of the strength of the lower cast for the convenience obtained in antagonization of the teeth. Fig. 63 illustrates properly formed upper and lower casts.

Separating Cast from Impression.—There are three steps to this operation: (*a*) removing any plaster overhanging the edge of the tray, (*b*) removing the tray from the impression, and (*c*) removing the impression from the cast.

A sharp plaster knife is used to cut away any overhanging plaster so that the outer edge of the tray is visible.

FIG. 63

If the impression is either wax or plaster, the outer surface of the tray should be slightly warmed over a Bunsen flame. The heat applied to the tray will soften the wax in contact with the tray, and the two may be easily parted. The plaster impression is as easily removed from the tray as a wax one, provided heat sufficient to soften wax is passed through the tray (Fig. 64). This is probably accomplished by slightly

expanding the metal of the tray, and also by generating a small amount of steam between the tray and plaster, or at least the expansion of the moisture upon the surface of the impression next to the tray. A modelling compound impression can be readily removed by rapping upon the outer surface of the tray. If the tray is of such shape that the two are dovetailed together, the rapping method may not suffice, and heat should be applied. This can be best done by placing it in a dish of cold water and applying slow heat. Care must be exercised not to apply too much heat or the modelling compound will be made very adhesive and will adhere both to the tray and cast.

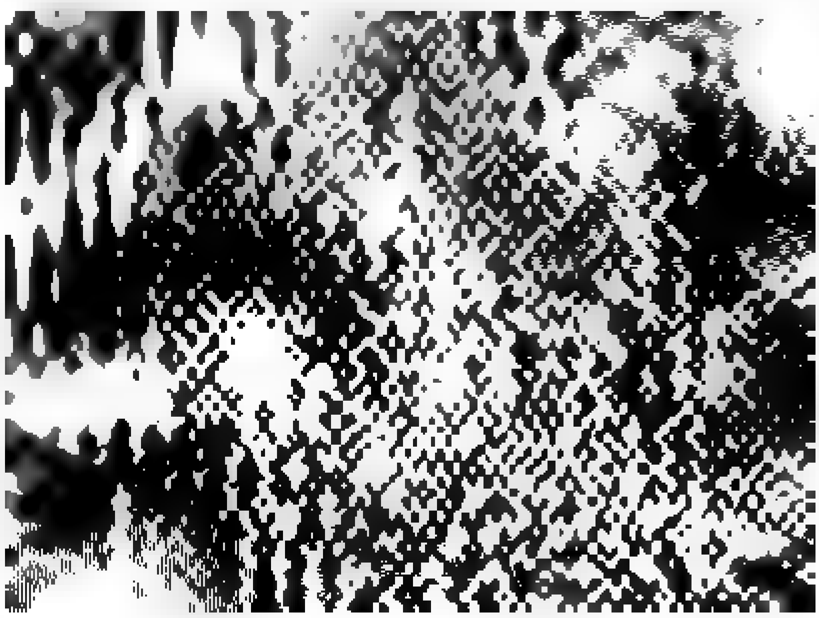


Fig. 64

Separating the impression from the cast can be neatly done by the exercise of care. Wax should be slowly warmed over a soft flame, and modelling compound in water. Either material should be removed from the cast by lifting the outer portions and turning them over upon the central mass, when it is easily removed. While a separating fluid is not necessarily applied to wax and modelling compound impressions, nevertheless, if a thin coat of sandarac is dried upon either impression before filling, it does facilitate the removal of the impression material, provided it has been slightly overheated.

Plaster impressions may be grouped into two classes to conform to as many procedures for separating them from their casts: (1) Flat impressions without undercuts. It is not necessary to remove these impressions from the tray, but by holding them with the cast downward and gently rapping upon the tray they will drop from the impression. (2) Prominent flaring processes. The plaster impression should be carefully pared away, with a sharp plaster knife, over the crest of the alveolar process, until the shellac line of demarcation is visible. The outer flange of the impression may then be flaked away. The remaining central portion, provided it is not keyed into place, may be lifted out by inserting the point of the knife or a wax spatula under any convenient edge of the impression. Should the central portion not yield to reasonable force, it must be carefully notched along the median line, when first one-half and then the other may be pushed inward.

Casts of Partial Cases.—The principle of construction of partial cases is the same as for full cases, but the technic varies to suit the conditions. Care must be exercised, in applying the separating fluid to the imprint of the teeth, that every portion may be thoroughly covered. This may be facilitated by applying an excessive amount of fluid, and using a rotary movement of the brush, or it may be applied with a pledget of cotton held in a pair of tweezers. While drying, the impression should be inverted so that any excess may not settle into the depressions of the impression. If the impression has been standing for a half-hour it should be dipped in water and the excess water shaken out just before filling. If the impression has been standing for several hours it should stand in water for three or four minutes before filling. This will aid the flow of the plaster and help to prevent air bubbles forming in the plaster of the cast. The filling plaster should be caused to flow down one side of the deep depressions (as the intaglio of the teeth), thus permitting the air to escape from the other. It is well also to have a tamping stick to press into the imprints of the teeth. (A small riveting hammer handle with the head cut off at the smallest part of the neck is an excellent tamper. Use

either end as convenience requires.) Each added portion of plaster should be jarred into place. An excellent way used by many for strengthening isolated plaster teeth of a cast is, as soon as the intaglio of the tooth is filled with soft

FIG. 65

FIG. 66

plaster, to force into the center of each tooth, for its entire length, a pin or a small diameter $\frac{3}{4}$-inch wire brad. Much care is required in removing the impression from the cast. It must first be carved down to the shellac line of demarcation before any attempt is made at breaking away the

impression. Fig. 62 shows a plaster cast with the plaster about the isolated teeth carved ready for breaking away the impression. Fig. 47 shows the cast.

Repairing Broken Casts.—Plaster casts may be broken accidentally. These may be nicely and strongly mended by uniting the sections with moderately thin, well-spatulated

Fig. 67

oxyphosphate of zinc cement. The sections should be supported until the cement has set sufficiently to be unyielding to their weight. The cast should then be undisturbed for at least a half-hour. If the cement is properly mixed and the portions of the cast are well pressed together the resulting union should be very strong.

Base-plate Outline.—With a soft lead-pencil the outline of the periphery of the denture is traced upon the cast. Figs. 65 and 66 show the base-plate outlines for an upper and lower denture.

These outlines represent average cases. In upper cases, difficult of retention, the palatal border should extend one-fourth inch or more backward; provided the impression is taken in such a manner that the soft tissues are held firmly against its bone foundation. The lower base-plate should always extend to approximately the external and internal (mylohyoid) oblique ridges; and in flat cases may extend slightly beyond these ridges, provided the edges are turned slightly upward.

However, with the modern trend in the technic of impression taking and cast forming a definite outline is established, thereby dispensing with the pencil traced outline.

Fig. 67 illustrates knives for cutting plaster. *A* is a common form; *B* is a Wilson knife having a $2\frac{5}{8}$-inch draw blade and a $1\frac{3}{8}$-inch push blade; *C* is a saddler's knife. The saddler's knife is a powerful tool for trimming the base of casts only. It is used with a rocking motion. All plaster knives need frequent grinding, as plaster, and especially Spence compound, quickly blunts the edge.

CHAPTER IV.

OCCLUSION AND CONTOUR MODELS.

Use.—Occlude, to strike against or close. This term is used to represent the teeth closed in their natural position of ease and rest. In this state the condyles of the mandible are in their normal retruded position in their glenoid mandibular fossæ, except in a few cases of acquired abnormal condyle articulation. It is apparent that to construct an artificial denture much data, other than a cast of the jaw upon which a base-plate is to be worn, is necessary, in securing which the occlusion model is an important factor. This occlusion model is a mass of material roughly outlined, and indicating the normal (probably the natural) relation of the teeth and jaws while at rest. The term "contour" is added to the title to imply that the mass of material has been molded or carved to such a form as will give the desired contour to the external soft tissues of the lower third of the face. Therefore if this mass of material which we call the occlusion and contour model is truly a model pattern it must be accurately reproduced in the essentials which it represents. However, this does not mean that the forms of the teeth should be carved in these models because the teeth are not to be made by the prosthetist (they may be obtained of the trade in much better form and strength than would be possible to produce in the dental laboratory); but it does mean that the lines indicated by the occlusion and contour models are to be permanently retained. This implies that thought and technic are to be employed in constructing these models. The student should have fixed in his mind the idea that the two primary objects of these models are to establish the position of the artificial teeth when at rest, and to give harmonious contour to the soft tissues covering the artificial dentures. In addition to these primary factors they are

used to record other important data, such as the high and low lip lines, also the median line and the slit of the lips.

Materials Used.—Wax and its combinations, modelling compound, resinous preparations, gutta-percha, and possibly plaster of Paris, may be named as the materials of which occlusion and contour models are made. These materials are used by the profession in the order named. The materials are attached to a base-plate, either a temporary one or the base-plate upon which the teeth are to be permanently mounted.

Wax is most commonly used as well as most misused for the purpose under consideration.

THE BITE.

This term is generally used in connection with the use of wax for obtaining the relation between the jaws and teeth. The word bite is of Anglo-Saxon origin, and means "split;" hence it is used in the sense of cut, lacerate, take severe hold of, and similar ideas. As applied to dental technology, it means to cut into a mass of soft wax with the teeth or bare gums. The term is inelegant and unscientific, and except for a very limited use it is non-expressive and associated with pernicious methods. The term should never be applied to occlusion and contour models. The term wax-bite is known by several other inelegant terms, as mush-bite, quash-bite, hunk-bite, and like terms. They all refer to the common practice of placing a mass of wax in the mouth and requiring the patient to bite into it. *To bite, cut:* As in 95 per cent. of cases the upper incisors overlap the lower incisors, to bite or cut means to bring the lower incisors forward and in contact with the upper incisors, thus inviting the patient to do the thing that is the *bête noir* of the dentist in mounting artificial teeth. The first requirement in obtaining the desired relation between the jaws and teeth is that the mandible shall be in its most retruded position. There is but one class of cases where the prosthetist should ever use the quash-bite, and that is where there are two or more natural teeth that have the required occlusion, but not

enough points of contact to support the casts while being attached to the *articulated frames*. If contour and other data provided by occlusion and contour models are not desired, then, and then only, may the quash-bite be used advantageously. As an illustration of an appropriate place to use a quash-bite, an imaginary case may be considered, consisting of a full lower natural denture and the six anterior, right first bicuspid and left second molar remaining in the upper jaw, the bicuspid and molar only in occlusion. Such a case would be the most favorable imaginable for casts with only two points of contact being self-sustained; and it is surprising to the student, no matter how he may have bolstered the casts with pieces of wax before mounting on the articulated frames, to find how much the finished dentures may be off from perfect occlusion. This is easily understood when consideration is given to the points of contact as fulcra and the distant positions for the left first bicuspid and right second molar as ends of a lever. A very slight movement at the fulcra will mean relatively a large amount at the ends of the lever. A modification of this supposed case would be having the retained second molar upon the right side; it would then be evident that some means of establishing the relationship of the left side would be necessary. As a result of the consideration of these imaginary cases this rule may be established: All partial cases, unless they have three or more widely separated points of occlusal contact, require occlusion guides. Quash-bites may serve an excellent purpose as occlusion guides. A suitable quash-bite for the case just considered would be to form a crescent-shaped mass of soft wax of a little greater thickness than the space between the teeth of the lower jaw and the gum of the upper jaw, and having imbedded in it a 14-gauge soft-iron wire stiffener. This prepared mass of wax is placed just inside the anterior teeth, with the ends occupying the edentulous spaces. The patient is then instructed to close and hold the teeth together firmly. The operator should press against the extruding wax, molding it firmly against the buccal surfaces of the teeth and gums. The patient is then instructed to open the mouth moderately

wide, when the operator should remove the wax with as little distortion as possible. It should then be made hard by placing in cold water, after which it is dried, trimmed of excess wax, and a small roll of soft wax placed in the imprint of the gums. It is then readjusted in the mouth and the mouth firmly closed upon it. This will correct any imperfections caused by manipulating the soft mass of wax. In using this wax occlusion guide care should be exercised to see that excessive portions of plaster or wax do not prevent the plaster casts going fully to place. Usually the casts or wax guides will require considerable trimming to permit of adjustment.

Occlusion models require a well-adjusted base-plate. The base-plate of the artificial denture being permanently constructed is the very best that can be provided for occlusion models. In fact, the best results can only be obtained in artificial dentures by first constructing the base-plate. This statement will invite disagreement, nevertheless the statement is tenable and will be demonstrated. However, where the single vulcanization method is to be employed in making an artificial denture, a temporary base-plate will necessarily be constructed for the occlusion model. There are several materials used for this purpose, as $\frac{1}{16}$-inch thick sheets of wax, paraffin, modelling compound, gutta-percha and "ideal base-plate," and similar preparations obtainable at the supply houses. These preparations are composed of shellac or a similar substance.

Methods for forming a base-plate of tin are used by a few operators, as swaging a base-plate of sheet block tin, and by burnishing tinfoil over the cast. Excellent results by the burnishing method may be obtained by the following technic: Adapt a sheet of No. 20 tinfoil to the plaster cast with the fingers and thumbs; the surplus is cut away with scissors, after which the tin is burnished with a steel or agate burnisher. Care should be exercised not to use sufficient force to mar the face of the cast. A second sheet is adapted to the burnished sheet by the fingers and thumbs, removed, and trimmed. A small dab of thick sandarac varnish is placed upon the center of the burnished sheet when

the second sheet is readjusted and burnished, beginning at the center and working outward. Layer after layer is thus added until the required thickness is obtained. After the first sheet of No. 20 is adjusted a heavier foil may be used if preferred.

Paraffin Base-plate.—Paraffin is found in the supply houses in the form of thin sheets put up in half-pound boxes. It is usually called pink wax because of the color the manufacturers have given it. This material is used by slightly warming it over a smokeless flame and adapting it to the plaster cast. The excess base-plate wax is trimmed away with a warm wax spatula at the indicated peripheral outline of the artificial denture. An excellent addition may be made to this paraffin base-plate by first adapting a sheet of tinfoil to the cast. This will prevent the paraffin, if overheated, from adhering to the cast, and also add some rigidity to the base-plate. The principal objection to wax or paraffin as a base-plate is that it is not rigid enough to retain its form while adjusting the occlusal model, and later the mounted teeth, to the mouth. For this reason some operators make this temporary base-plate of modelling compound, gutta-percha, or of the various resinous preparations offered for sale. The temporary base-plate having been formed over the cast, it is well to try it in the mouth and prove the correctness of its adaptation and peripheral outline. This is not very satisfactorily done with the less rigid base-plate, but with the permanent base-plates of vulcanite or metal it is a most important step in the procedure. Mention is made of this fact to impress the idea that the most commonly used method is the most unsatisfactory and unreliable one. The base-plate (when adjusted) is removed from the mouth, dried, and replaced upon the cast, a roll of softened pure yellow wax is molded over the ridge of the base-plate to the estimated length and fulness of the lip, when it is tried in the mouth and manipulated to the required contour. (The full details of contouring the occlusion model can only be properly considered under the subject of Esthetics, Chapter XVI.) The edge of the wax rim should come to, and thus indicate, the lip line. If the occlusion model is an upper one

to be adapted to a full lower artificial or natural denture, the occlusal border of the wax rim must be trimmed to evenly press upon the opposing denture. It is not necessary to trim so as to have perfect contact of the occlusal border, but there must be at least four well-spaced points of contact, then a small flattened roll of soft wax placed along the occlusal border and closed upon will make perfect contact. If the occlusion models are being formed for an upper and lower edentulous case, the occlusal border should represent the plane of the teeth (see Chapter I). This is accomplished by having the occlusal border of the upper model exactly at the slit of the lips and extending straight backward parallel with the imaginary line drawn from the base of the nose to the lower border of the external auditory meatus (Camper's line) or the line dividing the middle and lower thirds of the face (Fig. 1).

Modelling Compound Technic.—The following description is a quotation from Dr. Charles R. Turner, in the *American Text-book of Prosthetic Dentistry:*

"**For the Upper Jaw.**—To construct a bite-plate of modelling composition for the upper jaw, the cast should be placed upon its base on the work-bench with the distal portion toward the operator. The method of making the bite-plate in one piece proposed by Dr. W. W. Evans is to be recommended. Three-fourths of a cake of modelling composition is softened in warm water, kneaded in the hands until homogeneous, and rolled into an ellipsoid about two inches long. One side of this should be thinned out by pressure between the fingers, and the mass so placed upon the cast that the thinned portion projects slightly beyond the posterior margin of the plate outline. By manipulation with the thumbs the remainder of the compound is gradually worked forward so that the vault of the cast is covered by it to the thickness of about $\frac{3}{32}$ of an inch. The thickness of this may be readily gauged, for the cast chills the material as it comes in contact with it, thus hardening it, while the overlying soft portion may be pushed forward. When the top of the alveolar ridge has been reached, the compound should be carried over it and slightly beyond the plate outline, along the labial and

buccal surfaces, the most of the mass, however, remaining upon the ridge and being shaped to represent the occlusal portion of the bite-plate. The probable relation of this part of the artificial denture to the alveolar ridge and the probable fulness of the buccal and labial portions should be borne in mind and the compound disposed accordingly, since the bite-plate when completed should be a rough model for the denture in these particulars. It should be taken from the cast and its margin brought into close contact therewith around the plate outline. This is to insure firm retention of the plate in the mouth, which is of the greatest importance, and should be secured, even if it be necessary to make at this time the changes in the surface of the cast which provide for the adhesion of the future denture. The form of the bite-plate at this time is largely tentative, as it is purposed to complete its modelling when the bite is taken, in accordance with the requirements which shall then be indicated. During the process of forming the plate, to prevent adhesion, the hands should be wet and the compound occasionally taken off the cast to break up its adhesion while it is soft, and then replaced, but under no circumstances must the cast be wet, as this will injure it for subsequent use. Rubbing its surface with soapstone or talcum powder will effectually prevent the adhesion of the compound.

"It is possible to construct the plate in two portions, that in contact with the mucous membrane being made of one piece of modelling compound rolled into a thin sheet and adapted to the cast, that representing the occlusal portion being formed of a roll bent to the shape of the alveolar ridge, and made to adhere by dry heat. The occlusal portion is made of wax by some practitioners because of the greater ease with which it may be carved, but its softness and tendency to yield under pressure make it less safe than modelling compound in preserving a fixed distance between the jaws.

"**The Lower Bite-plate.**—The lower bite-plate is more easily made than the upper. With the cast face up on the work-bench, a piece of compound equal to about one-half of a sheet is softened and worked into a long uniform roll, bent to the shape of the alveolar process, and placed upon its

summit. With the thumbs and fingers it is worked down the lingual and labial sides to a point slightly beyond the plate outline, that portion over the ridge being shaped to represent this part of the future lower plate and made to correspond in outline to the arch of the upper bite-plate. It is removed and trimmed to the plate outline like the upper, its occlusal surface being left rough. If the lower plate must be very thin, it may be strengthened by imbedding in it a piece of iron or brass wire shaped to conform to the alveolar outline."

Modelling Compound Base-plate.—The preceding method, as described by Dr. Turner, consists of forming the base-plate and occlusion model of one piece. Another method is to form the base-plate of a thin sheet of modelling compound and building up the occlusion and contour portion with yellow or pink wax.

Technic.—The plaster cast is covered with a sheet of tinfoil or pattern tin, by adjusting the tin with the thumb and finger. It is not necessary to adjust the foil accurately, for the following step of adapting the modelling compound will perfectly adjust the foil. The modelling compound should be rolled or pressed into a sheet $\frac{1}{16}$ to $\frac{3}{32}$ of an inch thick. The sheet may be formed by rolling with a moistened wooden roller or pressing it with the fingers upon a warm plate of glass. The glass slab should be slightly lubricated with vaselin, or moistened with water, to prevent adhesion. The warm and pliable sheet of modelling compound is quickly and accurately adjusted to the plaster cast over the tinfoil, and trimmed to the peripheral outline of the desired plate. The tinfoil serves a double purpose; it renders easy the removal of the base-plate from the cast, and prevents soiling of the cast should the compound be overheated in any subsequent operation. Any portion of the modelling compound base-plate that may not be perfectly adjusted may be perfected by passing repeatedly over the Bunsen flame and conforming with the fingers slightly moistened.

Gutta-percha and the Resinoid Preparations.—These are obtained at the supply houses in sheets about $\frac{3}{16}$ of an inch thick. They are both manipulated in the same manner as

the thin sheets of modelling compound, and will not need further description.

Vulcanite Base-plate.—This form of base-plate is applicable only where there is considerable recession of the alveoli. It is apparent that a vulcanite base-plate must have considerable thickness for strength and rigidity; and admit of sufficient added material to attach the teeth and to give the indicated restoration without overdistending the supported soft tissues.

The advantages of a vulcanite base-plate are: (1) It detects a faulty impression before much work has been done. (2) It permits study of the retention of the artificial denture. If it is evident that the impression was defective, or that the devised scheme for retention is insufficient, a new impression may be taken and the mistakes corrected without much loss of time and labor. (3) It gives stability and proper support to the subsequent operation of construction.

The only disadvantage in the vulcanite base-plate, where it is indicated, is that the finished artificial denture has a portion of its substance vulcanized a second time. As rubber contracts every time it is vulcanized the revulcanized base-plate does necessarily slightly change form; however, it would be illogical to condemn the method for this reason unless repairing is unallowable. Some have thought that the revulcanization of a portion of the denture weakened it. This cannot be, as the revulcanized portion is next to the fulcrum (gum) and the fracture must begin in the surface farthest from the fulcrum, that is, in the portion but once vulcanized. Further, the base-plate being revulcanized is harder, more rigid and less flexible, hence is a firmer support for the superstructure. However, the student should know that it is essential that the heavy bearings of the base-plate upon the tissues must be properly located, and that there is danger of warping in the second vulcanization. This phase of the subject will be considered in the technic of double vulcanization.

Vulcanite Base-plate Technic.—A suitably prepared cast of plaster of Paris or Spence plaster compound having been obtained, it is preferably (though not necessarily) overlaid

with a sheet of thin tinfoil, after which a sheet of slightly softened paraffin (pink wax) is accurately adjusted to the cast over the tin protection. The excess wax and tin are cut away at the previously indicated peripheral outline for the base-plate. A roll of yellow wax $\frac{1}{8}$ inch diameter (made by rolling between two flat surfaces) is adapted by finger pressure to the labial and buccal periphery including the tuberosities in the upper, but also extending the entire length of lingual periphery in the lower base-plate. The wax rim is pressed into place with the finger, but it is luted and carved with a warmed wax spatula and knife. This additional is not shown in Fig. 68, but the result is shown in Fig. 70. The technic of this wax rim is further described in the chapter on Aluminum Base-plate (X). The advantages of the peripheral additions are rigidity of base-plate, and a finish margin. The edge of the wax base-plate is then carefully sealed to the cast with a hot wax spatula.

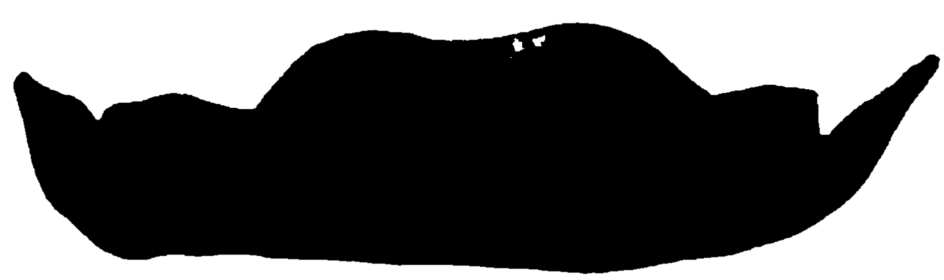


FIG. 68

The cast and model base-plate is flasked in a Star or Snow flask, the flask opened, model base-plate removed, surface of the cast finished (either silex or tin), packed with rubber, flask closed, and the case vulcanized. After the vulcanization is complete and the vulcanizer cold, the base-plate is removed from the flask, cleaned of plaster, the edges filed, and the outer surface scraped to give a suitable surface for the attachment of the rubber at the time of second vulcanization. The inner surface, or the surface to rest upon the soft tissues should not be changed except to remove any excrescences produced by defects on the surface of the cast. Fig. 68 shows a vulcanite base-plate.

This outline sketch has introduced several laboratory processes, which will be discussed in their proper place.

Metal Base-plates.—When an artificial denture is to be constructed upon a metal base, the base-plate is formed either by the casting or swaging method. It is obvious that the base-plate constructed as a component part of the finished artificial denture is the very best base-plate for the occlusion and contour models. Therefore the vulcanite and metal base-plates are to be much preferred to the temporary base-plates formed of wax or of the gum or resinous preparations.

The base-plate, of whatever material, having been adjusted to the mouth, the walls of the model are to be built up of either pure yellow beeswax, white wax, pink wax (paraffin), or modelling compound. Their rigidity is in the inverse order as named. The ease of manipulation is in the order given. The yellow wax is the least rigid, but because of its ease of manipulation it is most commonly used for building up the occlusion walls. The student should constantly bear in mind this one deficiency of yellow wax, although the material is commended to him because of its desirable properties for subsequent procedures. No matter, at this time, which material is selected, the material will be manipulated in the same manner, so far as construction is concerned. Having placed the base-plate on the cast, a cylindrical roll of the softened material of sufficient length to cover the crest of the alveolar ridge, and in diameter varying from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch, according to the amount of space to be filled, is conformed by manipulating with the fingers and thumbs to the ridge portion of the base-plate. The plastic material is luted to the base-plate by the use of a hot spatula. The labial and buccal surfaces are added to or carved away as may be necessary to give the required contour for the support of the lip and cheeks. This first shaping is entirely by guesswork; however, this is only to give it general form for trying in the mouth.

The esthetic manipulation of the plastic material to the mouth will be treated of in the chapter on Esthetics. The occlusal surface of the plastic rim must be a perfectly flat surface, and as this edge forms the occlusal plane or teeth plane, it must be correctly located. The perpendicular

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length of the plastic rim is indicated by the length of the lip, and is located by the slit of the mouth when the lips are perfectly relaxed and at rest. The slit of the lip marks the anterior border of the plastic rim, but from that point backward the length is indicated only by the naso-auditory-meatus line (see Chapter I, Fig. 1). The occlusal surface is carved from or added to until the required plane is obtained.

The method of testing this wax plane is to place the occlusion model in the mouth, and a straight edge placed against the occlusal surface and extending 4 inches from the mouth

Fig. 69

will indicate whether the occlusal surface of the occlusion model is parallel with the naso-auditory-meatus line or not (Fig. 69). Should the student have trouble in carrying this naso-auditory-meatus line with his eye, he can stretch a string so as to include the two points named, thus ascertaining whether the string and straight edge are parallel or not. A suitable straight edge may be formed of a thin sheet of metal, horn, or vulcanite. It should be 2 inches wide at one end and 6 inches long. After the correct occlusal plane has been established and any deficiencies noticed

filled in, the occlusion model is pressed upon a flat surface with sufficient force to give a true even plane to the occlusal surface of the model. At all times, in using any force upon a base-plate, it should be upon the plaster cast, thus avoiding any possibility of warping. Prevention is always better than remedying.

The upper occlusion model having been perfected, it is removed from the mouth and placed in cold water.

The lower model is built up in the same manner as the upper and then adjusted to the upper in the mouth. The upper model is kept in cold water except during the few moments at a time that it is needed in the mouth while adjusting the lower. By keeping the upper model cold and rigid, all change resulting from closing the mouth will be in the softer, lower model. The lower model must be manipulated until it has a suitable vertical length, contour, and an even pressure upon the occlusal surface of the upper model. The occlusion models having been satisfactorily adjusted, they are removed and placed in cold water to thoroughly chill.

The patient should be instructed regarding the next step of the operation, that is, retruding and protruding the chin. Often it will require considerable time and patience to educate the patient in placing the chin as requested. It is not necessary; in fact, it is better that the patient should not place the chin in the extreme protruded position. It should be placed in the extreme retruded position and be protruded at least one-fourth of an inch. A hand mirror is often an aid to the patient in learning to protrude and retrude the chin. If the patient does not readily do as requested, the operator may demonstrate with his own mouth the desired movements. The patient having become proficient in the exercise, the occlusion models are adjusted in the mouth. Should either of the models be refractory and not keep its place, it may be temporarily "glued" into place by sprinkling the inner surface with powdered gum tragacanth.

The patient is requested to retrude the mandible and close the jaws; then to protrude and close. These instructions

being satisfactorily obeyed, the patient is requested to retrude the mandible, close the jaws, and hold the occlusion models firmly together. The head is then moderately tilted backward. The patient is requested to swallow. The act of deglutition necessarily places the mandible in the retruded position.

As a further test that the condyle is at its normal retruded position the operator may place his fingers upon the anterior portion of the temporal muscles and request the patient to moderately pinch the wax occlusion models together three or four times. If there is distinct contraction of the anterior portion of the temporal muscle the condyles are in their normal rest position; but if the mandible is protruded there

Fig. 70

will be hardly a perceptible contraction of the muscle. The student may study the value of this diagnostic sign in his own person by noting the contraction when he compresses the molars and none when the incisors are in contact and compressed.

While the occlusion models are thus firmly occluded, the lips are parted and the median line of the face is marked upon both models with a sharp instrument.

The patient is requested to raise the upper lip as high as possible by muscular action. Then a horizontal line is made indicating the highest point at which the lip can be raised. The lower lip is depressed and the low lip line traced. The cheeks are distended and two perpendicular lines are drawn upon each buccal surface. These buccal

lines must extend into both the upper and lower models and are used as location marks only (Fig. 70). There are now registered upon the occlusion models the length of the lips, the median line of the face, and the high and low lip lines. Besides these lines used in mounting the teeth, there are four buccal lines used in conjunction with the median line to properly assemble the models when out of the mouth.

Condyle Path.—The next record to be made by means of the occluding models is the condyle path. By reference to Figs. 2 and 8, and Chapter I, it will be seen that there is a great variation of the condyle path, that the principal portion of the path is a straight and more or less oblique line, but if the mandible is protruded to its extreme position the condyle has described a "straightened out" letter S rather than a nearly straight line; therefore in taking this measurement the extreme protrusion is not desired, but one-fourth of an

Fig. 71

inch or a little more will include the portion required. It is obvious that if the condyle moves forward and glides down the eminentia articularis (articular tubercle), and the incisal portions of the occlusion models are brought together, the distal or molar portion of the occlusion models cannot be in contact; also that if a measure is taken of the forward movement of the mandible and of the separation of the distal portion of the models, sufficient data is obtained to reproduce the condyle path. These measurements are easily obtained with Dr. Snow's "bite gauges" (Fig. 71). The bite gauges consist of a small plate of metal with the under side so formed as to be easily attached to the occlusal surface of the lower wax model; the upper surface of the bite gauge carries a blunt metal spud. A bite gauge is mounted near each end of the lower model by wetting the metal and pressing it, flush into the occlusal surface of the model. The patients are told that when the lower model is replaced they are to protrude the

mandible and close the jaws until the incisal portion of the models are in contact. By this means the spud on top of the bite gauge will be forced part way into the occlusal surface of the upper model, thus in one operation marking the forward position of the mandible and the distal separation of the occlusion models. The lower model is removed from the mouth and the bite gauges carefully removed so as not to distort the marks made by them. At a future time these bite gauges will be returned to their place in the occlusion models and establish the condyle path.

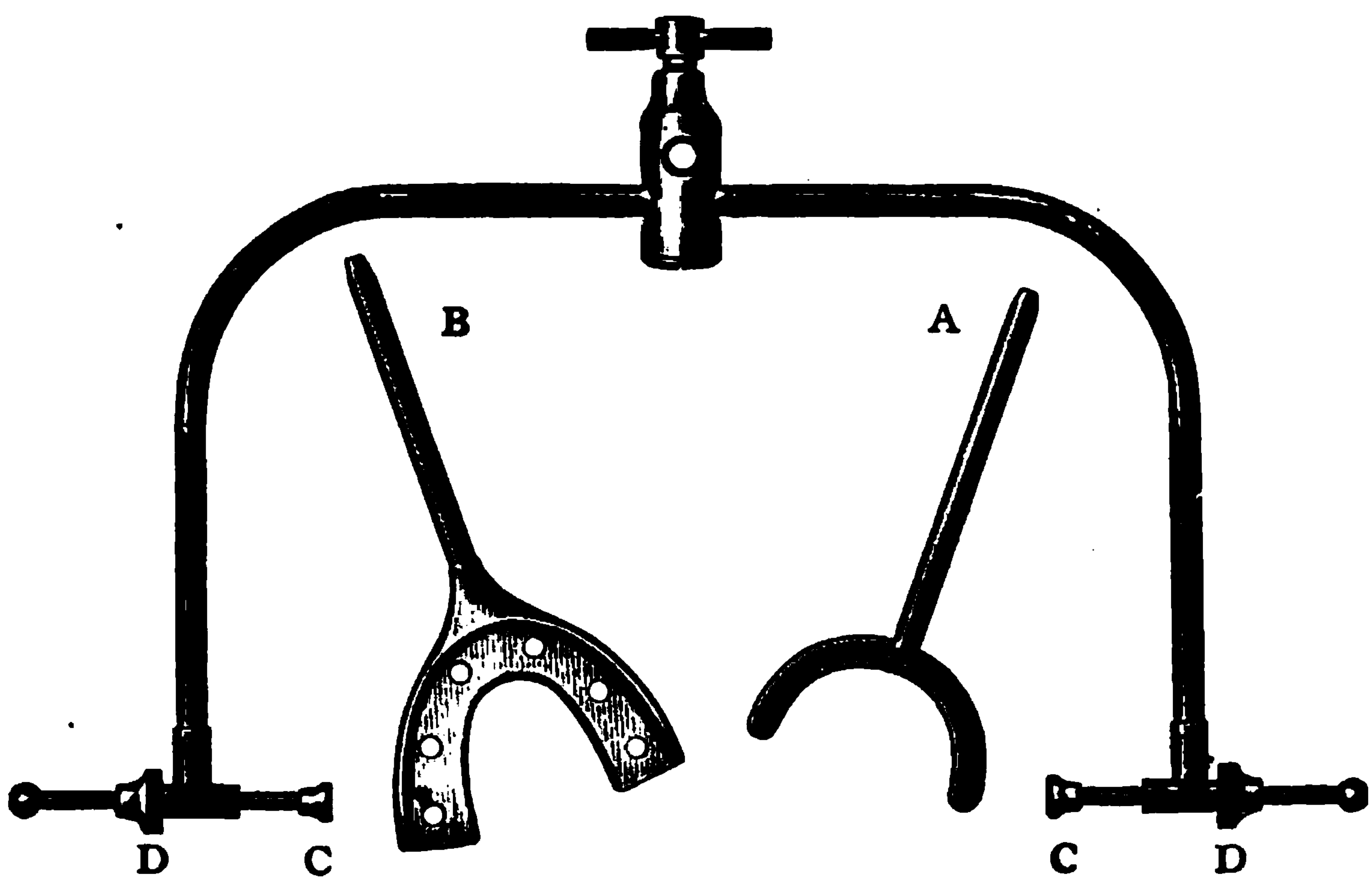

FIG. 72

Snow Face Bow.—The remaining data to be obtained is the *relation of the alveolar process of the maxilla to the condyles.* This measurement is obtained by the Snow face bow, an invention of Dr. George B. Snow, of Buffalo, N. Y. The instrument consists of a bow-shaped bar of metal with a sliding condyle bar at each end, and at the center carrying a universal clamp and fork for holding the occlusion model. *A* and *B* are two forms of the fork or mouth piece (Fig. 72).

Before attempting to use the face bow the outer tubercle of the condyle should be accurately located. By referring

to the skull (Fig. 2, Chapter I), it will be seen that the mandibular fossa in which the condyle rests is just in front of the external auditory meatus, that it is inclosed by the auditory process at the back, the distal end of the zygoma above, and the tubercle of the zygoma or articular tubercle in front. This fossa may be located by pressing with the finger upon the face of the patient about one-half inch in front of the tragus of the ear, and at the same time requesting the patient to widely open the mouth. The outline of the depression or fossa should be accurately located. By again referring to Fig. 2 it will be seen that the crest of the tubercle of the condyle, when in the retruded position, is a little in front of the center of the glenoid fossa. As the mouth is closed the tubercle of the condyle may be easily felt in a spare patient, but with much difficulty in a very fleshy patient. However, the fossa can always be detected and the location of the tubercle of the condyle closely estimated. It may be well to mark the location of the tubercle of the condyle upon both sides of the face. This may be done with a very soft-lead pencil or a small piece of court plaster.

Face-bow Technic.—The fork of the face bow is removed from the clamp and the prongs of the fork sufficiently warmed to permit of their being inserted into the body of the upper occlusion model. The tail of the fork should be in the median line of the face and parallel with the imaginary extension of the occlusal surface of the model. A slight variation from the indicated location of the fork will be of no consequence, as the universal joint will accommodate itself to this. The face bow is adjusted to the face by sliding the condyle bars in so that an equal length of each is on the inside of the bow (the notched rings are a means for measuring), and the head of the condyle bars will rest firmly upon the tubercles of the heads of the condyles. There is sufficient spring in the face bow to aid in adjusting and supporting it. The condyle bars should be securely clamped in their adjusted position. The wax occlusion models are placed in the mouth in their normal retruded position, the universal clamp of the face bow is loosely placed over the tail of the fork, and the heads of the condyle bars are swung and sprung into position

upon the tubercles of the condyles. The bow is held in position by the left hand while the right hand fastens the universal clamp securely. The condyle bars should again be universal clamp securely (Fig. 73.) The condyle bars should again be inspected to see that they are properly located.

Fig. 73

While the patient is firmly holding the occlusion models, the lips are parted and if the models are properly occluded, as indicated by the median and four buccal lines, the models may be securely united by inserting Dr. Snow's (Fig. 74) four-

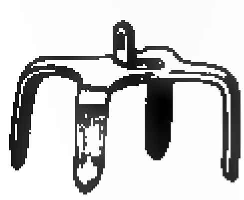

Fig. 74

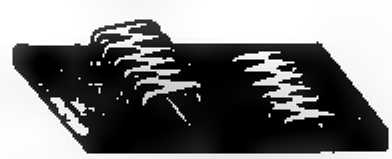

Fig. 75

pronged staple upon each side; or, steel belt lacings (Fig. 75) may be used. The condyle bars are drawn away from the face, the mouth opened, and the united models attached to the face bow removed.

The order of the measurements just given is such as to

economize the time of the patient; however, by reversing the order of measurements, a slight change of technic and detaining the patient longer will assure greater accuracy.

The face-bow measurement is first obtained and the casts and wax occlusion models mounted upon the antagonizer. This procedure may be much expedited without detriment by adding an accelerator to the luting plaster. The wax occlusion models are then returned to the mouth with the bite gauges in place and the protruded or forward position of the condyle marked.

The Christensen method of recording the condyle path consists of placing a small mass of softened wax at the ends of the lower occlusion model, in place of the Snow bite gauges. With either method the occlusion models are united with the four-pronged staples. The occlusion models are then returned to the antagonizer and it adjusted.

Attention.—With either method for obtaining the condyle path equal pressure must be obtained at the regions of the molars and incisors. The danger is, that excessive pressure will be made at the molar region, and that the incisal portion of the lower occlusion model will be lifted from the gum, thereby recording a steep condyle when only a slight one exists. *Test the relationship with a flat spatula.*

Resumé and Observation.—The object of this chapter has been to differentiate between the wax-bite and the occlusion and contour models; also to teach their use and how to construct them.

It should be observed that the wax-bite (often called the quash-bite) is very limited in its usefulness, that it is very inadequate for any purpose except as location guides for partial cases. The quash-bite used for constructing complete artificial dentures belongs to that class of short-cut procedures essayed by charlatans and ignorant persons. No operator with an intelligent conception of the anatomy and physics of mastication can place any confidence in such methods. It is true that the quash-bite has been very largely used in the past and is too much used today; nevertheless it is an empirical method, and can never be associated with successful prosthesis.

It is apparent that the occlusion and contour models are the scientific and only practical method of gaining the necessary data for constructing useful artificial dentures; also that measuring instruments are necessary for obtaining data that can be acquired in no other way. In preceding sections of this chapter the Snow face bow for obtaining the relation of the alveolar processes of the maxilla to the condyle, and the bite gauges, for recording two points in the movement of the condyle in its path, have been presented. Other important instruments are those of Prof. Gysi.

GYSI MEASURING INSTRUMENTS.

Prof. Alfred Gysi, of Zurich, Switzerland, gives a very lucid description of his instruments for measuring the condyle path, the retruded position of the condyle, and the rotation points of the condyles, beginning with the January, 1910, number of the *Dental Cosmos*. Since that time Prof. Gysi has extensively revised his theories and instruments. His latest work appeared in the 1913 *Digest* and through courtesy we are permitted to present the revisions.

Fig. 76 shows the various instruments in knock-down, and the parts named.

Fig. 77 shows the condyle path register attached to the lower wax occlusion model by means of the horseshoe plate, and the method of making the measurement.

Figs. 78 and 79 show the method of completing the measurements of the vertical or condyle path.

Fig. 80 shows the method of holding and using the lateral path register. With ground glass resting upon the vertical lead-pencils, the register is moved laterally to mark the starting- or resting-points. The patient is then requested to move the mandible repeatedly right and left.

Fig. 81 and legend shows how to obtain the angle from the tracing on the ground-glass plate.

Fig. 82 shows the incisor path register in place upon the upper wax occlusion model.

Fig. 83 shows the tracings made of the incisal path upon the horseshoe plate.

Fig. 76.—The parts are as follows: Nos. *1-2*, upper and lower parts of articular frame which carry the upper and lower model bows; Nos. *1 A* and *2 A*, upper and lower model bows; Nos. *3-3*, straight incisor guide pin and curved incisor guide pin. The curved pin is used only when mounting models or setting anteriors; No. *3 A*, small pin for all set screws; Nos. *4-4*, framework of condyle path register; Nos. *4 A-4 A*, pencil holders and pencils of condyle path register; Nos. *5-5*, lateral path register; Nos. *6-6 A*, stand and gooseneck for holding condyle path register and models; No. *7*, horseshoe plate; No. *8*, degree plate for measuring inclinations of paths; No. *9*, incisor path register.

FIG 77.—The forward and downward movements of the condyles are recorded by the horizontal pencils of the condyle path register. The ends of the pencils are placed opposite the condyle heads, a card is held against the face with its lower edge parallel with the broad plate of the register, and the mandible is caused to exercise its different movements. The movements of one condyle at a time are thus recorded

FIG. 78.—Shows the mode of measuring the angle formed by the condyle path and the lower border of the recording card.

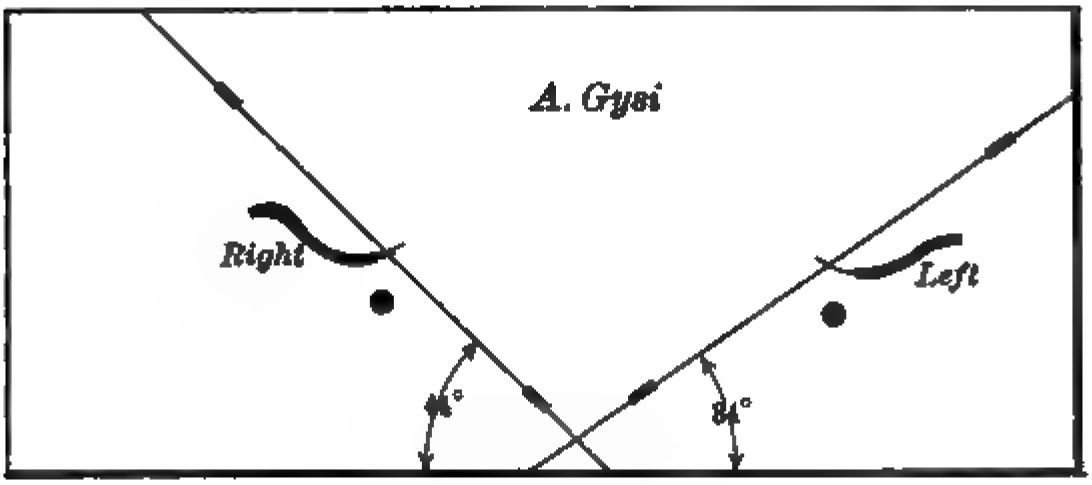

FIG. 79.—Shows the completed measurements of the condyle path

FIG. 80

Fig. 81.—Lateral condyle paths recorded and strengthened. Line drawn from "resting point" in one path to "resting point" in the other, and perpendiculars erected at these points. Angles may be measured with the little plate used for measuring forward paths.

Fig. 82

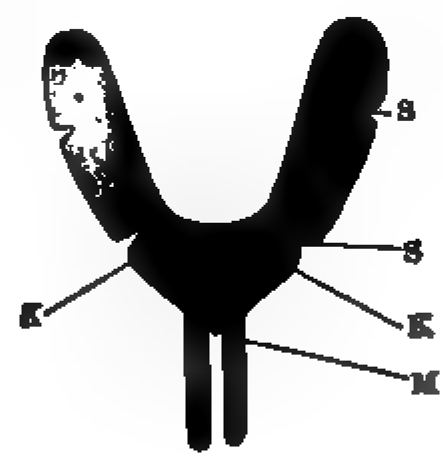

Fig. 83

Fig. 84 shows the horseshoe plate, with its tracing of the incisor path register in black wax, mounted upon the lower wax occlusion model, and their assemblage for obtaining the tracings.

Fig. 84

The casts, occlusion models, and measurements are now ready for their respective antagonizors.

CHAPTER V.

ARTICULATORS AND ANTAGONIZORS.

Definition.—Articulator is a name applied to apparatus of many designs. Of these many designs it may truly be said that a few are good, that a few others are bad, but that the most of them are indifferent. Unfortunately the name is a misnomer, but it is so universally used that it seems a useless expenditure of time to more than explain the anomaly. The term is used in the anatomical sense, and means "a joint," hence the instrument can only rightly be termed an articulator because of its hinge joint, not because of the operation for which it is designed. The instrument is used to assemble artificial teeth in occlusion, and they should be in antagonization. The operation for which the instrument is intended is to occlude and antagonize the teeth and not to articulate the teeth, as is usually stated, for teeth, both natural and artificial, can articulate only upon their proximate mesial and distal surfaces; but not upon their occlusal surfaces. The name "articulation" for assemblage of the teeth is a misnomer, therefore it is absurd to name the instrument in conformity with the misnamed operation.

Under the general term "articulator" two distinct types of instruments are included, the simple hinge-joint class called *articulator* (Fig. 85), and the class which make a pretense of imitating the temporomandibular articulation called *anatomical articulator*. Hereafter in this book when the hinge-joint type is referred to it will be called *occlusion frame,* and when the other type is meant it will be called the *antagonizor*.

Occlusion Frame.—An occlusion frame is a dentist's apparatus to secure the open and shut arrangement of artificial teeth.

Antagonizor.—An antagonizor is a dentist's apparatus to secure anatomical and mechanical arrangement of artificial teeth.

History.—Guerini gives credit for the original invention of this device to J. B. Gariot, about 1805. Many forms of the apparatus have since been devised, a few of which are of historical interest because they denote professional thought and endeavor.

Hin

Fig. 85

August 28, 1840, Daniel T. Evans, of Philadelphia, obtained a patent for an apparatus having slot and pin joints, by means of which, as he expressed it in his specifications, "the lower plate is allowed a motion at the joints similar to that which is admitted by the condyloid processes of the living subject" (Fig. 86).

In 1858 Dr. W. G. A. Bonwill, of Philadelphia, invented his instrument. He presented the instrument and his studies of anatomical antagonization before the American Dental Association at Niagara Falls, N. Y., in 1864. Dr. Bonwill may be justly called the father of anatomical antago-

nization and antagonizors because of the volume of research work and writing he did upon the subject. Undoubtedly his genius has inspired all later work in this field of endeavor (Fig. 87).

In 1889 Dr. Richmond S. Hayes, of East Bloomfield, N. Y., received a patent for an antagonizor which embodied at least one new feature. He probably was the first to attempt to reproduce the downward motion of the condyle. Prof.

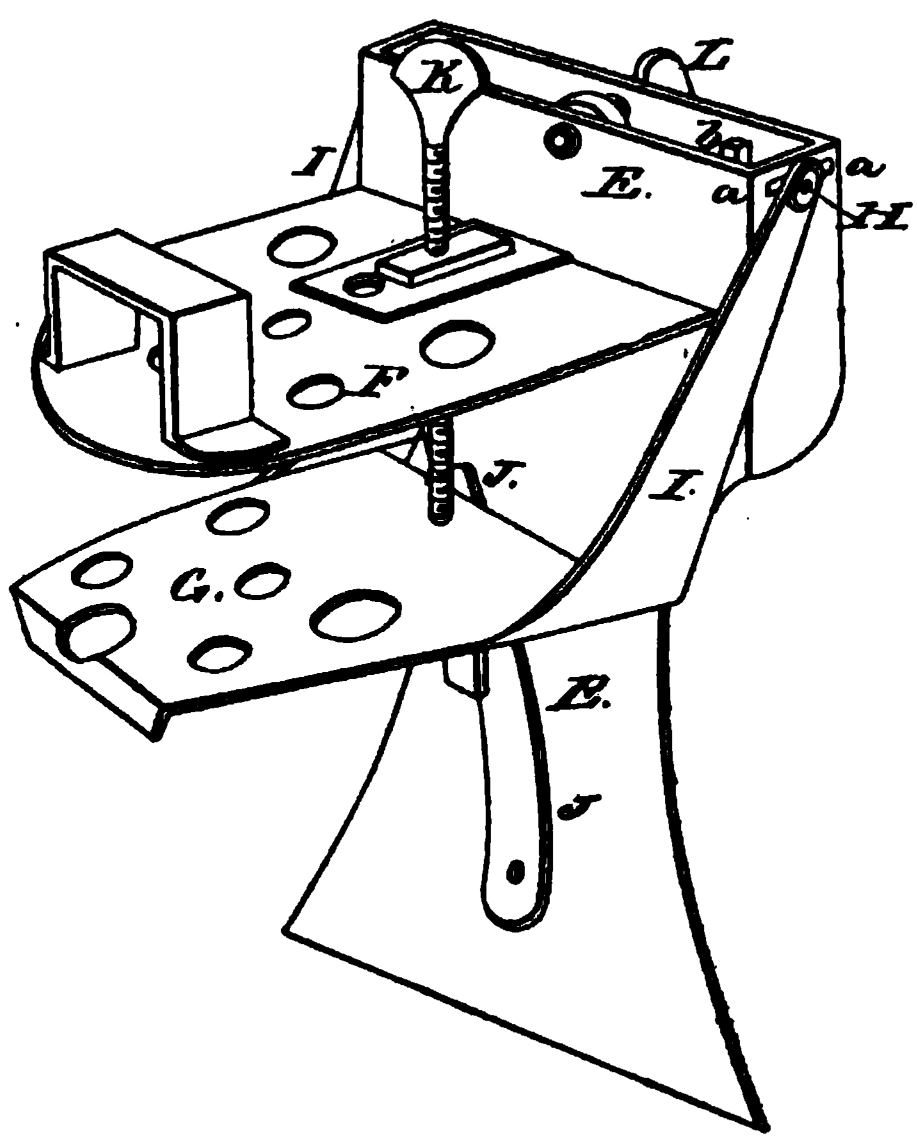

Fig. 86

Gysi says, speaking of the "forward and downward slope": "This fact had previously been noted by two anatomists—Luce, of Boston (1889), and Count Spee (1890)—but their work remained unknown to dentists for some years." It will be noticed that the earlier date given by Prof. Gysi is the same as of the patent paper of Dr. Hayes.

The Walker antagonizor (Fig. 88): Dr. George B. Snow, of Buffalo, in his paper published in the *Dentist's Magazine*,

July, 1907, says: "In 1896 Dr. W. E. Walker, then of Pass Christian, Miss., now of New Orleans, obtained a patent upon an antagonizor constructed in much the same manner as the Bonwill, but with adjustable joints for imitating the direction of the condyle path. Dr. Walker is the first one who clearly recognized the fact that there was a considerable variation in the inclination of movements of the condyle upon the

Fig. 87

articular tubercle. He obtained another patent upon an instrument by which the inclination of the condyle path could be ascertained. This he called a 'facial clinometer.' But he also lost sight of the second condition of the problem, the correct location of the casts in the antagonizor. Dr. Walker made a close study of his subject, and his papers, published in the *Cosmos* for 1896 and 1897, are well worth reading. They are, in fact, nearly exhaustive so far as they

go, and he is entitled to great credit, much more than he has received for their presentation."

In 1899 Dr. A. De Witt Gritman, then of Buffalo, but now of Philadelphia, and Dr. George B. Snow introduced the Gritman antagonizor and the Snow face bow.

In 1901, in *Ash's Quarterly*, and the *Cosmos* for October, 1905, Prof. Carl Chistensen describes his antagonizor. In the paper previously referred to, Dr. Snow says: "He

Fig. 88

(Prof. Christensen) showed at that time his simple and practical method of ascertaining the inclination of the condyle path, and transferring it to the antagonizor, thus taking the last step necessary for the full solution of the problem of the correct antagonization of full dentures. But he did not recognize the importance of correctly locating the casts in the antagonizor, and in the one which he constructed, which much resembles that of Dr. Walker, he unfortunately

designed it so that the casts cannot be placed near enough to the joints."

In the *Transactions of the Odontological Society of Great Britain*, 1903, J. B. Parfitt described his antagonizor with its curved condyle path constructed for each case. This instrument required that the ascertained condyle path for each individual case be cut out of a sheet of metal and clamped to the jaw of the antagonizor.

In 1907 Dr. George B. Snow introduced the New Century Antagonizor (Fig. 89). This instrument is built upon the lines of the Gritman. The frame is higher arched and therefore more open at the back than its predecessor. It

Fig. 89

has each bow secured with two set screws. The instrument is provided with an extra pair of bows, the lower of which is extra long and the upper bayonet-shaped, thus accommodating any thickness of casts. The straight upper bow has a sleeve for marking its position, so that it may be removed and returned at will. The position of the lower bow is registered by the plaster securing the lower cast. It has straight-slotted adjustable condyle paths, and metal spuds for obtaining the inclination of the paths. The central spiral clamping spring is effectual and convenient. There is an extension of the slot pin for supporting the face bow. The face bow accessory of this instrument has been described (Chapter IV). It is a simple, well-constructed, and effectual

instrument. It reproduces most of the essential movements of the mandible.

Fig. 90 is the Gysi adaptable antagonizor assembled and each part named.

When the antagonizor is used without the help of the measuring instruments it is important to place all casts so that the occlusal plane is exactly parallel to the table on which the antagonizor stands, as the degree scales are

Fig. 90

founded on a corresponding horizontal plane. It is also important to have the front of the casts at an equal distance of 10 cm. from the rear supporting pins, thus forming a Bonwill triangle.

Fig. 91 is the Gysi Simplex, which is a simplified form of the Adaptable Antagonizor.

Fig. 92 is the improved form of the Snow New Century Antagonizor. It is designated the "Acme." This instrument is provided with the Bennett lateral mandibular move-

ment; also, it has the incisal guide pin, a very valuable attachment upon any antagonizor.

Fig. 91

Fig. 92

Fig. 93 is the new Hall Antagonizor. It is constructed upon an entirely different principle than any other instrument herein shown.

Fig. 93

MOUNTING.

How Mounted.—The two types of instruments under consideration are for distinct operations. The antagonizors may be used as an occlusion frame, but the occlusion frame cannot be used as an antagonizor. The operation of occlusion is a simple one, while that of antagonization is complex, and includes occlusion as one of its factors.

The occlusion frames are designed to hold the plaster casts in a fixed position, but for convenience of mounting the teeth upon either cast, the other should be removed sufficiently to give finger room for manipulation; hence the instrument is provided with a hinge joint, thus permitting

removal without loss of relationship. As the instrument is designed to hold the casts in a fixed position, it can make no difference in what position the casts are mounted in the frames, so long as the position is convenient for manipulation. Usually the incisor section of the casts are placed at the front, but in some partial casts it may convenience the workman to place the bicuspid section to the front; the relationship of the casts, however, will be the same.

The antagonizors being designed to hold the casts and mounted teeth in many positions, it is necessary that the casts shall be definitely and accurately located; therefore specific instruction is required for occlusion frames as a class, and each antagonizor; however, of the antagonizors the Snow and Gysi only will be further considered in this chapter.

Mounting upon Occlusion Frames.—The plaster casts and wax-bite, or occlusion and contour models, as may be had, are assembled and united with a little melted wax. These are placed upon the lower part of the occlusion frame, the upper part is adjusted with the set screw so that it will be just free of the upper cast, and the set screw is fixed with the jam nut (Fig. 85). The casts are united to the frame with a soft mix of plaster; however, if the plaster casts have been standing a few hours so as to become dry, they should be saturated with water just before mixing the attaching plaster. Some of the soft-mixed plaster is placed upon a slightly oiled surface; any convenient substance, as glass, marble, metal, wood, a piece of paper, or, sheet celluloid (best), may be placed upon the work bench and the plaster placed upon it. The occlusion frame containing the casts is placed on the soft plaster and firmly pressed into place. The upper portion of the occlusion frame is raised, soft plaster placed upon the upper cast, and the raised portion of the frame pressed firmly into it. The soft plaster may be smoothed by trowelling with the plaster spatula (Fig. 28). If the casts have been made unnecessarily thick it may be necessary to trim them down, otherwise it may be difficult to adjust them in the occlusion frames.

Mounting upon the Snow Antagonizor.—The antagonizor is prepared for the case by adjusting the set screw and

making firm its jam nut, so that the bows are parallel to each other. The bows are then adjusted to give the necessary space to insert the assembled casts and models. This is accomplished by sliding the lower bow either up or down and using either the straight or bayonet-shaped upper bow, as may be required to accommodate the case. The lower cast should be so trimmed that the occlusal surfaces of the wax models shall be parallel with the lower bow. The case being mounted without the face bow, the assembled casts and models should be centrally located, with the portion representing the mesial incisal angle of the lower central incisor teeth four inches from either condyle joint. The assemblage is then united with plaster as described for occlusion frames.

Mounting with the Face Bow.—The set screw with its jam nut having been fixed as described in the preceding paragraph, assembled casts, occlusion and contour models, and face bow, as described in Chapter IV, are ready for mounting in the antagonizor. The condyle bars of the face bow are pushed in to their limit and made fast with their jam nuts. The head of each condyle bar has a depression which fits over the extended slot pin. The heads of the condyle bars are adjusted to the antagonizor by springing the face bow sufficient to permit the heads to slip over the slot pins. The lower cast rests on the lower bow; however, the cast must not be attached to the lower bow until the occlusal surface of the occlusion model is parallel with the horizontal portion of the lower bow. This relationship of cast and bow may be secured either by trimming the cast (which is rarely necessary), or by pushing in or pulling out the lower bow. The lower bow being adjusted, it is secured with its set screws. Either the straight or bayonet-shaped upper bow is adjusted as may be necessary to clear the upper cast. The casts are then made fast to the bows with plaster as previously described (Fig. 94). The plaster luting having thoroughly hardened, the face bow is removed. The remaining step is to secure the inclination of the condyle path. Loosen the condyle clamps so the slotted condyle bars may move freely, unhook the spiral spring, readjust the bite gauges. (See Chapter IV.) The bite gauges being adjusted in both wax

Fig. 94

Fig. 95

Fig. 96

Fig. 97

models and the incisal portion of the wax models in contact, the slotted condyle bars must assume their respective positions, when they are firmly clamped (Fig. 95). The bite gauges are removed and the spiral spring attached (Fig. 96).

A modification of this method consists in first mounting the casts and wax occlusion models upon the antagonizor with the face bow, then returning the wax occlusion models, mounted with the bite gauges (or small balls of soft wax—Christensen method) to the mouth and obtaining the measurements of the condyle paths. The retention spring of the antagonizor is released and the condyle path clamps loosened when the wax occlusion models are returned and the condyle paths adjusted.

Mounting upon the Gysi Antagonizor.—Fig. 97 shows the Adaptable Antagonizor with the condyle path register used as a face bow, mounted upon the stand with the gooseneck, ready for attaching the cast to the upper "model bow" with plaster. The illustration is self-explanatory.

Mounting upon the Hall Antagonizor.—The method of mounting the casts, occlusion and contour models upon the Hall Antagonizor is described in Chapter VI in the portion devoted to the Hall instrument and method. (See Figs. 142, 143 and 144.)

CHAPTER VI.

RUBBER AND VULCANITE.[1]

Rubber.—India rubber, or caoutchouc.

Vulcanite.—A chemical compound of caoutchouc and sulphur.

CAOUTCHOUC.

History.—Caoutchouc is a native Indian name. India rubber is a name given the material because its early use in Europe was to remove black-lead pencil marks from paper. Dr. Priestley, the distinguished discoverer of oxygen, mentions this use in a publication of 1770. Caoutchouc must have been known in America at a very early period, because balls made from the gum of a tree, lighter and bounding better than the wind-balls of Castile, are mentioned by Herrera when speaking of the amusements of the natives of Haiti, in his account of the second voyage of Columbus. In a book published in Madrid, 1615, Juan de Torquemada mentions a tree which yields it in Mexico, describes the mode of collecting the gum, and states that it was made into shoes. More exact information was furnished by a French Academician, who visited South America in 1735. While the Indians used it more than three hundred years ago for water bottles and gum shoes, it was only used in the United States and Europe for erasing pencil marks, until about 1820, when it was applied to water-proofing cloth. As caoutchouc became hard and brittle in cold weather and sticky in hot weather, many experiments were made to overcome this objectionable quality, which resulted in the discovery of vulcanite in 1843.

[1] The history, physical and chemical properties of rubber and vulcanite are taken from the author's chapter in Turner's American Text-book of Prosthetic Dentistry; however, much enlarged upon in this edition.

Physical Properties.—Caoutchouc is a hydrocarbon prepared from a watery milky emulsion called "Latex," which is procured from the bark of many tropical and semi-tropical trees. In a few instances the latex is in the wood as well as in the bark.

Scientists are not certain of the physiological function of the latex, but it has been suggested that it may be a reserve food material, to provide a protection against bark injury, or it may be a waste product of plant metabolism.

The latex, which is obtained by making incisions in the bark, consists of an emulsion of rubber globules in a watery fluid. The size of the globule or caoutchouc cell varies from 0.5 to 3 microns. The cell has very much the appearance of an ameba; is mobile and moves with considerable rapidity in its watery medium.

The rubber cells are coagulated by heat and smoke (the native Para method); boiling; natural drying; diluting with water; and treating with acids. The acid treatment (acetic and citric) is in general use in plantation rubbers.

Porritt[1] states that the method of coagulation and the quantity of reagent appear to be important factors in determining the quality of the resultant rubber. He also states that "It is a remarkable fact that Para rubber, produced by a primitive process in the Amazon Valley, should be superior to that prepared under careful scientific control and supervision from the same species of tree in Asia." It is also noteworthy that the best quality of Para gum may be kept for years without "perishing" (a technical term denoting oxidation). This keeping property is undoubtedly much favored by the creosote in the smoke used in coagulating the gum from the latex. Gums coagulated by other processes may spoil in a few months, owing probably to the action of both bacteria and oxidation. Some of the vulcanized rubbers behave in a similar manner, that is, perish with age. Here the problem without doubt is further complicated by the

[1] Chemistry of Rubber, by B. D. Porritt, B.Sc. (Lond.), F.I.C. Published by D. Van Nostrand Company, New York, 1913.

filling agents used, also by the method and degree of vulcanization.

In the Amazon Valley there are over three hundred varieties of rubber-yielding trees, shrubs, vines and plants. The most highly valued latex producers are the Heveas of the Amazon Valley. There are thirty or more varieties of the Heveas, and "Hevea Braziliensis" is considered the finest quality. The term Para rubber is a commercial term, and is applied to the best grades of the Amazon Valley gum. Other commercial terms are Plantation; Ceara Scrap; Java; Amazon Ball; Para Negrohead; Assare Scrap; etc. Para is the port on the Amazon River from which the gum is exported. The name "Plantation" designates the rubber procured from cultivated gum trees. The other names refer to locality and peculiarities of the gum. The crude gum as it is found upon the market is not a pure article, but contains from 2 to 60 per cent. of the following ingredients: (1) resins; (2) nitrogenous bodies, proteins, peptones; (3) carbohydrates; (4) inorganic matter. They may contain also dirt, bark, sand, introduced mineral matter, moisture, and free acid. The removal of the impurities and the resultant loss of weight is a very important commercial item. The plantation gum has the lowest percentage of loss in purification, therefore is the more profitable to the manufacturer.

The pure caoutchouc is a colorless transparent substance. It has no definite melting-point, but from 150° to 200° C. it becomes a viscous liquid which does not solidify again. At approximately 126° C. it goes into a viscoid state which hardens again on cooling; this temperature is usually spoken of as its fusing-point. It is a typical member of a class of bodies called colloids. Its density has been given as 0.900. Another series of samples of plantation rubber yielded values varying from 0.9097 to 0.9261. The gum is insoluble in water or alcohol, and is not acted upon by alkalies or acids, except when the latter are concentrated and heat is applied. It is soluble in ether, chloroform, bisulphide of carbon, naphtha, petroleum, benzol, and the essential oils, and in many of the fixed oils by the aid of heat.

Porritt gives the following list of mixing materials as in common use:

Accelerators of Vulcanization.—Litharge; calcium hydrate; magnesium oxide or carbonate.

Colored Fillings.—Antimony; arsenic or mercuric sulphides; lead peroxides; ferric oxide; chromic oxide; lead chromate (cold cure); ultramarine; Prussian blue (cold cure); graphite and lamp-black.

Colorless Fillings.—Whiting; barium sulphate; lithophour; French chalk and zinc oxide.

Organic Fillers.—Paraffin wax; pitch; rosin; tar; old vulcanite (as crumb and dust).

Porritt further states that there are but three explanations of the union of caoutchouc and sulphur:

(*a*) A solidified solution of one substance in another.

(*b*) An absorption of one material by another.

(*c*) Chemical union.

The theory of solidified solution is entirely discredited. The absorption theory by Ostwald, published in 1910, has not been substantiated; while the chemical theory of C. Otto Weber, published in 1903, has, according to Porritt writing in 1913, the preponderance of evidence in its favor.

Purifying.—In the manufacture of India rubber the first operation is the purification of the crude material. The impure rubber is cut into minute shreds and is washed by powerful machinery immersed in water, which releases the solid impurities. The washed gum is then placed on iron trays and dried in a room heated by steam. The material then undergoes a process of kneading under very heavy rollers which causes the adhesion of its various pieces to each other and ultimately yields a mass or block of India rubber so compact that all air-holes, other cells, and interstices disappear.

Chemistry of Caoutchouc.[1]—India rubber, as is well-known, is the product of the coagulation of the milky juice of a large number of trees, creepers, and shrubs. The com-

[1] The writer uses as his authority for this paragraph and the subsequent ones upon the Chemistry of Vulcanite, "The Chemistry of India Rubber," by Carl Otto Weber, Ph.D., published by Charles Griffin & Co., Limited, London; J. B. Lippincott Company, Philadelphia, 1903.

mercial article can hardly be expected to be homogeneous, and still less a pure product in the chemical sense. Besides accidental impurities of sand and fragments, it contains a greater or less amount of oily and resinous matter, which varies greatly even in the same brand of rubber. Para rubber contains from 1 to 2 per cent.; Logus rubber from 3 to 7 per cent.; Borneo rubber from 6 to 21 per cent.; and African flake may contain as high as 64 per cent. Lascelles-Scott gives the composition of a brand of unnamed origin:

	Per cent.
India rubber (gum)	37.13
Albumin	2.71
Resins	3.44
Essential oils	traces
Sugar	4.17
Mineral matter	0.23
Water	52.32

The pure Para gum consists of soluble and insoluble portions, the latter averaging about 3.5 per cent. The soluble portion has a formula of $C_{10}H_{16}$, and is the portion with which the sulphur combines to form vulcanite. The formula for the insoluble portion is $C_{30}H_{68}O_{10}$.

VULCANITE.

History.[1]—Charles Goodyear, of New Haven, Conn., discovered the process of curing or vulcanizing India rubber in 1843. Thomas Hancock, of England, has been credited with making this discovery contemporaneously; but his own writings state that he had seen small samples of Goodyear's work, and that after much experimenting he produced the same thing; so the priority of the discovery undoubtedly belongs to Goodyear.

On January 30, 1844, a patent was granted to Charles Goodyear for making soft or flexible rubber that would resist the action of the usual solvents of caoutchouc, and would not

[1] This historical sketch of vulcanite is made up largely from the monograph, "Instruction in Vulcanite," by Prof. E. Wildman, M.D., D.D.S., Philadelphia; Samuel S. White, 1867.

be affected by cold or heat if the temperature were not raised above the vulcanizing-point. The mixture he preferred was caoutchouc, 25 parts; sulphur, 5 parts; and white lead, 7 parts. This produced soft vulcanite.

The process of making hard rubber was patented by Nelson Goodyear May 6, 1851. His formula consisted of one-half pound of sulphur to a pound of caoutchouc and one-half pound of any one of a long list of earthy substances.

A patent was granted to Charles Goodyear, Jr., "For improvement in plates for artificial teeth," dated March 4, 1855. He says: "The best compound I believe to be one pound of India rubber or gutta-percha (or of the two combined in suitable proportions) with a half-pound of sulphur, together with a suitable quantity of coloring matter. To obtain a suitable color, I mix with caoutchouc or gutta-percha, vermilion, oxide of zinc, oxide of iron, or any coloring substance that will stand the necessary degree of heat with the action of sulphur. This compound, after having been molded, is subjected to heat for about six hours, and in so doing I gradually raise the heat to about 230° F., say in half an hour, and then, unless there be a considerable quantity of foreign matter present, the heat may be raised, quickly as may be, to about 295° F.; otherwise, I raise the heat more slowly and keep the compound at about that temperature for the remainder of the six hours, and then allow the whole to cool down, when the process will be completed."

A patent was granted in June, 1857, to H. H. Day for vulcanizing very thick pieces of rubber. To accomplish this he explains that he mixes with the matter prepared for vulcanization a substance that will prevent its becoming spongy or cellular, by absorbing the sulphur gases as fast as generated. The material which he proposed to employ for this purpose is ordinary fire clay, but other substances capable of absorbing the gas may be employed.

In Austin G. Day's specification we find some interesting remarks upon the nature of rubber compounds. In contradistinction to Nelson Goodyear's hard and inflexible substance, he claims his compound to be a hard, but highly elastic material obtained by a process differing from that of

N. Goodyear's in the length of time, in the degree of heat, in the proportion of the ingredients, and in the mode of equalizing the temperature.

Day's composition is one pound of purified Para rubber and one-half pound of sulphur.

He remarks: "In the vulcanizing process there is eliminated during the whole operation a constant discharge of sulphuretted hydrogen and other sulphuretted gases, which must have means of escape through the pores of the mass while being vulcanized. By my present improved management of the heat in vulcanizing, by raising it very gradually, step by step, to the highest point, I am enabled to vulcanize pieces of an inch or more in thickness with great uniformity and perfection. A mixture containing earthy matter may be vulcanized in much shorter time than one consisting of caoutchouc and sulphur alone, and yet be solid, owing to the earthy matter facilitating the escape of the gases generated in its substance during the process. At the same time such compositions are destitute of elasticity and flexibility. For a piece five-eighths of an inch thick, the time required for vulcanizing is thirteen and one-half hours:

It is held at	275° F., for 6 hours
Then raised to and held at . .	280° F., for 3 hours
Then raised to and held at .	290° F., for 2 hours
Then raised to and held at	295° F., for 2 hours
Then raised to and held at	300° F., for ½ hour"

Composition of Vulcanite for Artificial Dentures.—As the formulæ of the various makes of rubber are "trade secrets" of the manufacturers, our knowledge is limited to the general specifications of patent papers and the writings which detail

ı and others.

hard flexible vulcanite are

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· which the product is de-

for coloring, controls, or to

in dentistry is known as

important use is for vela

for cleft palates. It contains sulphur to the extent of about one-fifth of the weight of the gum. Hard vulcanite, sometimes called ebonite, contains by weight one-half as much sulphur as caoutchouc.

Some of the formulas given by Prof. Wildman are:

DARK BROWN.

Caoutchouc	48 parts =	66⅔	per cent.
Sulphur	24 parts =	33⅓	"

RED.

Caoutchouc	48 parts =	44.44	per cent.
Sulphur	24 parts =	22.22	"
Vermilion	36 parts =	33.33	"

DARK PINK.

Caoutchouc	48 parts =	42.76	per cent.
Sulphur	24 parts =	21.38	"
White oxide of zinc	30 parts =	26.78	"
Vermilion	10 parts =	8.90	"

GRAYISH WHITE.

Caoutchouc	48 parts =	28.57	per cent.
Sulphur	24 parts =	14.28	"
White oxide of zinc	96 parts =	57.14	"

BLACK.

Caoutchouc	48 parts =	50	per ecnt.
Sulphur	24 parts =	25	"
Ivory black, or drop black . .	24 parts =	25	"

JET BLACK.

Caoutchouc	48 parts =	40	per cent.
Sulphur	24 parts =	20	"
Ivory black or drop black . . .	48 parts =	40	"

The S. S. White Dental Mfg. Co., have standardized their rubbers by using the following formulary for all rubber except pink and white: Gum, 50 per cent.; sulphur, 16 per cent.; dyes and fillers, 34 per cent. This formula provides a ratio of three to one of gum and sulphur, and the other formulæ given have a ratio of two to one. A ratio of gum four parts to one of sulphur produces a vulcanite on the border-line between hard and soft vulcanite, while the ratio of five of gum to one of sulphur is typical soft or velum vulcanite.

Scientists state that $C_{10}H_{16}S_2$, or sulphur 32 per cent., is

the highest combination of caoutchouc and sulphur that has been produced; therefore the slight excess of sulphur in the two to one mixture, and any sulphur not chemically combined serves only as a filler. The reduced quantity of sulphur in the S. S. W. new rubbers is the explanation for their increased toughness.

Any dentist can make a comparison of the toughness of various brands of rubber by vulcanizing a strip of each of the rubbers to be tested under the same conditions, and observe the degree of flexion required to break them, also note the character of the fracture.

It is questionable if the usual dental methods for vulcanizing ever combine all of the sulphur in the rubber mixture without producing an over hard and brittle vulcanite.

If pure caoutchouc is burned, there should be but about 3 per cent. of dark ash remaining. Sulphur and vermilion (mercuric sulphide) leave no ash, hence the percentage of ash from rubber containing these materials should be less than 3 in the ratio of the amount of these materials to the caoutchouc. Some rubbers leave as high as 60 per cent. of ash. It would be reasonable to suppose that the strength would be reduced in ratio to the amount of the ash, but this is not true, as the pure gum and sulphur produce the strongest vulcanite; the red and black are nearly the same strength, although the black rubber will leave a much larger ash than red, because the coloring matter is animal charcoal composed largely of phosphate and carbonate of lime, while the mercuric sulphide would be entirely volatilized. The oxide of zinc and other earthy matter in the pink and white rubbers have a very deleterious effect upon the flexibility and tenacity of the vulcanized rubber, so much, in fact, that these light-colored vulcanites are not one-fourth as strong as the brown, red, or black.

Physical Properties of Vulcanite.—Vulcanite is hard, flexible, elastic and horn-like in texture. Dr. George B. Snow gives the specific gravity of a specimen of black vulcanite as 1.1974, and that of the same piece before vulcanizing as 1.1333. The specific gravity varies, as it is much

affected by the coloring matter, and is also increased by the temperature and time of vulcanization. Caoutchouc expands upon heating. Dr. Snow says: "Rubber expands by heat more rapidly than any other solid body. Its rate of expansion at ordinary temperature, from 70° to 90° F., is over six times that of iron, about five times that of brass, and nearly four times that of zinc, which is the most susceptible to expansion by heat of any of the metals except mercury. Its rate of expansion is known to increase as the temperature rises, but it has not been definitely determined." In vulcanizing soon after chemical action begins (248° F.), expansion ceases and shrinkage commences, the latter being much affected by the contained foreign matter, by a high or low temperature, and by a long or short time of vulcanization. Its increased specific gravity is due to this shrinkage.[1]

The usual solvents of caoutchouc have but little action upon vulcanite, and no agent which can be tolerated in the mouth has any action upon it. It is susceptible of a high polish. It is very opaque, and therefore does not imitate well the appearance of the mucous membrane. It is a very poor conductor of thermal and electrical changes, in consequence of which it is not conducive to the health of the tissues upon which it is worn. If well vulcanized it is exceedingly dense, but may be made porous by careless manipulation. Great care should be used in vulcanizing rubber that is to be worn in the mouth, and the patient should be thoroughly instructed in cleansing it.

New rubber can be added to old vulcanite by reheating; hence vulcanite dentures can be easily repaired. It is unnecessary to add a solution of rubber to vulcanite to aid in its repair, as the solvent has no action upon the vulcanite, only leaving a thin layer of soft rubber upon the roughened vulcanite; attachment is better accomplished by heat and pressure.

[1] Dr. Snow has made a very fine and proper distinction in the two words —contraction and shrinkage. Contraction is the antonym of expansion; and shrinkage is a permanent reduction in form. Shrinkage takes place while the rubber is under continued heat and the chemical change is taking place; whereas contraction takes place with the cooling process only.

These terse statements of the physical properties of vulcanite may profitably be amplified.

Specific Gravity.—The specific gravity of vulcanite varies with its composition and method of vulcanization. The following table is sufficiently extensive to elucidate these facts. Pure Para gum has a specific gravity of 0.915, and sulphur a specific gravity of 1.95; therefore velum rubber containing 1 of S and 5 of gum should have a specific gravity of 1.06; also, hard vulcanizable rubber containing 1 of S and 2 of gum should have a specific gravity of 1.26. The table on page 201 gives four representative dental rubbers, with the coloring matter named in the first column and the specific gravity of a specimen of each in the second column. The third column gives the specific gravity of each vulcanized under a Lewis gas regulator set at 320° F. for one hour and twenty minutes. The fourth column gives the specific gravity of the rubbers vulcanized at the same time as the specimens in the third column, but they were not flasked; they were wrapped in tinfoil and submerged in the water. The second column shows a great variation in the specific gravity of unvulcanized rubbers due to the various coloring materials; the third column shows a still greater variation due to the quantity and conductivity of the coloring material; also this column shows the coloring material exerts a direct influence upon the denseness of the vulcanite, as shown by the increased specific gravity. The pure black vulcanite was increased in specific gravity 0.0496, the red vulcanite 0.0853, and the gold dust 0.0622; therefore gold dust shows a condensation over the pure black equivalent to a specific gravity of 0.0126, and the red over the black of 0.0357. The fourth column shows remarkably the action of the heat and its conduction upon the vulcanizing process. The tin and water being far better conductors of heat than the plaster investment, the red and gold-dust vulcanite show a further increase of specific gravity, while the pure black shows a decrease of specific gravity to the extent of 0.0008 less than the unvulcanized rubber. This is explained by the poor internal conductivity of the pure black and the rapid induration of the surface.

This increasing condensation suggests the question: Does revulcanization cause shrinkage? It does. This was demonstrated by revulcanizing six times (under the conditions described in the preceding paragraph) a piece of red vulcanite 66.3 mm. long. Each time revulcanized it was carefully measured and showed an average decrease of 0.25 mm.; or, approximately, 0.5 per cent. for each vulcanization, that is, a total of 3.2 per cent. of its length for the six revulcanizations.

Table of specific gravity.	Coloring material.	Before vulcanized.	After vulcanization in flask.	Vulcanized in tinfoil, not flasked.
Para caoutchouc	Smoke	0.915		
Sulphur	......	1.95+		
Mercuric sulphide	......	8.2		
Velum rubber (Doherty's)	Smoke	Less than 1.0	Less than 1.0	
Pure black rubber (Doherty's)	Drop black	1.1523	1.2019	1.1515
Bow spring (White's)	HgS	1.6410	1.7263	1.7421
Gold dust (Traun's)	Aluminum powder	1.1321	1.1943	1.1972

Dr. Snow states graphically the relative expansion of vulcanite and certain metals. Other authorities give the coefficient of expansion as follows:

Cast iron	0.0000055
Zinc	0.0000140
Mercury	0.0000998
Vulcanite	0.0000636

Thus it is seen the authorities (Heil and Esch and Thorpe) for these figures make the expansion of vulcanite more than four times as much as for zinc, the most expanding of the solid metals.

Text-books state that rubber expands until vulcanization begins and then shrinkage takes place. This is true. The author devised a special vulcanizing apparatus for demonstrating the expansion and shrinkage of vulcanization. It consisted of a brass flask open at the top and a plunger cover with a hole through which a thermometer is placed in contact with the rubber. The flask is placed in an open receptacle filled with glycerin nearly to the top of the flask

A two-pound weight is placed upon the plunger cover, also an upright making connection with a recording needle which enlarges ten times. Heat is applied by an electric heater. Red rubber was placed in the flask and the following record obtained: From room temperature to 200° F., one-eighth inch, and from 200° to 250° F., one inch. The needle remained stationary for a short time, then dropped back one-eighth inch and so remained until the end of vulcanization (320° F., 1 hour), after which it moved back about three-sixteenths inch. As both rubber and sulphur melt at approximately 250° F. and vulcanization begins at 248° F. it is evident that expansion continues until the ingredients are melted and union begins, and that the combined shrinkage and contraction is greater than the expansion, as shown by the increased specific gravity in well-vulcanized rubber. However, the improvised recording vulcanizer did not record perfectly the shrinkage of vulcanization because the indurating rubber had greater resistance than the weight applied. The shrinkage took place within, in the direction of least resistance, thereby forming several large spaces. There was no evidence of gas formation associated with these spaces as so evident with porous vulcanite when "something has gone wrong."

A practical application of these physical properties cannot be made until after a study is made of the chemistry of vulcanization, to which attention is now given.

Chemistry of Vulcanization.—Vulcanization consists of the chemical union of caoutchouc and sulphur, probably producing a series of compounds having the formula $C_{10}H_{16}S_2$ for the highest combination, and $C_{100}H_{160}S$ for the lowest, with a series from the lowest to the highest.

Vulcanization can be brought about either by the cold or the hot process, and by using with the latter either the dry or the wet method. The essential requisite is to secure the union of the sulphur with the polyprene ($C_{10}H_{16}$).

The cold process is by the use of sulphur monochloride, and is only suitable for very thin layers of rubber, being, therefore, not applicable for dental use. An attempt has been made to sell to the profession office rights for the use

of a porcelain enamel for facing vulcanite dentures. This method was based upon the cold vulcanization process. While the results were an improvement upon ordinary pink rubber, the product lacked the translucent effect of fused porcelain, its durability was uncertain, and the process was long and tedious.

Mr. Weber, in the work previously referred to, says: "We turn our attention first to the question of the general action of sulphur upon India rubber at high temperatures. The sulphur bath method might appear from several points of view the most suitable method of studying this question, but after a number of attempts I abandoned it in favor of the method of subjecting carefully prepared homogeneous mixtures of Para rubber with a definite amount of sulphur to the action of heat. Again, in this case we have the choice of several methods of heating, but the one of heating pieces of Para mixture of uniform thickness to vulcanizing temperatures when immersed in water appeared to me the most satisfactory, as it involves the minimum of loss of sulphur by evaporation.

"The experiments were carried on with strips cut from a calendered sheet, 3 mm. in thickness—a mixture of 100 parts of Para rubber with 10 parts of pure precipitated sulphur. These strips were vulcanized in a phosphor-bronze digester.

"The digester is provided with a thermometer tube (thermometer in mercury), a pressure gauge, and a blow-off valve. In the digester a porcelain beaker is suspended so that it is clear of the bottom. The digester is filled to about one-quarter of its capacity with water; the beaker is completely charged with water, and a number of the strips to be experimented upon immersed in it. The digester is then closed, rapidly heated to the required temperature, and maintained thereat, either by carefully adjusting the gas burner, or by means of some form of thermoregulator. At regular intervals one of the strips is withdrawn after blowing off steam and rapidly opening the digester, which is then immediately closed again to continue the series. The time error caused by these successive withdrawals does not

exceed four minutes per sample. Of course the water lost by the blow-off steam is from time to time made up with boiling water.

"The strips thus withdrawn are marked, and subsequently cut into very fine threads, which are freed from every trace of uncombined sulphur by extraction with acetone in a Soxhlet extractor. The greatest care was employed to render this operation perfect, every sample being subjected to a three days' continuous extraction. The extracted samples were dried in a current of carbonic acid in the water oven, and, until analysis, were preserved in carefully stoppered glass tubes.

VULCANIZATION OF PARA RUBBER.

Duration of vulcanization.	Temperature of vulcanization. 120° C. S.%	125° C. S.%	130° C. S.%	135° C. S.%	140° C S.%
30 mins.	0.71	0.71	0.99	1.76	
60 "	1.18	1.32	1.44	2.17	
90 "	1.31	1.67	2.04	2.36	
120 "	1.62	1.91	2.32	3.92	5.07
150 "	....	....	....	4.02	
180 "	1.78	2.11	2.94	4.18	6.05
240 "	1.93	2.22	5.00	5.50	
300 "	2.25	2.35	5.27	6.74	
360 "	2.60	3.80	5.82	6.88	
420 "	3.71	4.04	6.04	6.97	
480 "	3.94	4.31	6.33	7.13	

"About one gram of each of these samples was used for analysis. The sulphur determinations were all, without exception, carried out by Carius' method, as the results by the much simpler and more expeditious method proposed by Henriques were found to be liable to an error approaching 0.1 per cent. in magnitude. In this manner the result obtained were as detailed in the table above.

"These figures amply suffice to demonstrate indisputably the fact, even quite recently again denied, that the vulcanization of India rubber with sulphur involves the chemical combination of these two substances, at any rate so far as the vulcanization of Para rubber is concerned.

"That different brands of India rubber behave very differently in the vulcanization process is a well-known

fact, but what we know at this moment respecting the composition and chemical relationship of these different brands entitles us to assume that, although their behavior under vulcanization may not be identical with the Para rubber, it will be more or less closely analogous to it."

Following this, Mr. Weber gives a tabulation of his experiments with Upper Congo, Beni River, Ceara, and Borneo rubber for the same duration of vulcanization and for 125° C. and 135° C. He then sums up these experiments thus:

"The extremely interesting results here tabulated remove all doubt that the vulcanization of India rubber is a chemical process resulting in the formation of a polyprene sulphide. The rate at which the sulphur enters into combination with the India rubber hydrocarbon (polyprene) is characteristic for each brand of India rubber. Some of the above series were repeatedly investigated, always with the same result.

"There arises now, of course, at once the question as to the nature of the process by which sulphur enters into combination with the polyprene, whether the polyprene sulphide or sulphides formed are addition or substitution products. Certainly what we already know respecting the chemical nature of India rubber leads us to infer that the vulcanization process consists essentially in the formation of an addition product of sulphur and polyprene. This assumption, however, requires support in view of the fact that quite a number of writers, from Payen to most of the recent authors, declare that vulcanization is accompanied by the evolution of hydrogen sulphide, thereby implying that the process is a substitution and not an addition process. Indeed, most of the recent authors on this subject state this in so many words. We shall therefore have to subject this point to a careful examination.

"Assuming the compound of polyprene and sulphur, which indisputably forms in the vulcanization process, to be a substitution product, it follows with absolute necessity that for each 32 parts of sulphur combining with the polyprene, we must obtain 34 parts of hydrogen sulphide. Now, in the process of vulcanization as practically carried out, we obtain on an average a product containing, say, 2.5 per

cent. of combined rubber. Consequently the vulcanization of one ton of India rubber, on the above assumption, would be bound to yield very nearly 60 pounds of hydrogen sulphide, or approximately 18,000 liters. Considering that in a number of factories the amount of India rubber vulcanized daily largely exceeds one ton in weight, we should expect to find the vulcanizing rooms of these factories reeking with gas. As a matter of fact, however, there is scarcely ever a trace of this gas to be discovered in the rubber works' atmosphere, and the very rare cases in which its presence becomes noticeable may always be considered as an indication of something having gone wrong.

"In the vulcanization of 'hard rubber' goods (ebonite, vulcanite) faint but distinct traces of hydrogen sulphide are generally, perhaps always, observable, but they could not be ascribed to the vulcanization process proper—the combination of polyprene with sulphur—which process, if it consisted in the substitution of hydrogen for sulphur, should cause a perfectly torrential evolution of hydrogen sulphide, seeing that hard rubber contains at least 20 per cent. of combined sulphur.

"It is therefore certain that if hydrogen sulphide forms at all in the vulcanizing process, its amount is utterly inadequate to support the assumption that the process of vulcanization is a substitution process.

"Laboratory experiments on this question lead to exactly the same conclusion. If the experiments are carried out with technically pure Para rubber under conditions absolutely precluding the escape of any gaseous product of the reaction, very minute traces of hydrogen sulphide may sometimes be observed; but in a considerable number of carefully devised experiments with highly purified Para rubber no hydrogen sulphide at all could be detected.

"If, on the other hand, the 'insoluble' part of India rubber is mixed with sulphur, and this mixture is subjected to a vulcanizing temperature, say about 135° C., a considerable evolution of hydrogen sulphide takes place, due to the formation of a substitution product of this insoluble body, $C_{30}H_{68}O_{10}$, with sulphur. This substitution process certainly

proceeds much slower than the vulcanization process of India rubber (polyprene). Under the same conditions of temperature and the time under which polyprene forms a vulcanization product containing 4 per cent. of sulphur, the above-named insoluble constituent forms a substitution product containing at most 0.7 per cent. of sulphur.

"From these facts we are justified in drawing the following conclusions:

"1. The India-rubber hydrocarbon, polyprene ($C_{10}H_{16}$), combines with sulphur without evolution of hydrogen sulphide. The vulcanization process of India rubber is, therefore, an addition process.

"2. The insoluble constituent of India rubber, which forms only an insignificant proportion of the technical product, not exceeding 5 per cent. of the total, combines with sulphur under vulcanizing conditions at a very slow rate, with evolution of hydrogen sulphide and with the formation of a substitution product.

"The above conclusively settles the question regarding the general chemical aspect of the vulcanization process, but it confronts us with the further question respecting the quantity of sulphur combining with India rubber in this process, as well as the more intimate structure of the compound thus formed."

Interesting and instructive as the work of Mr. Weber is, the limits of this chapter will not permit us to follow him in detail, but only to give his conclusions:

"The process of vulcanization consists in the formation of a continuous series of addition products of polyprene and sulphur, with probably a polyprene sulphide, $C_{100}H_{160}S$, as the lower, and $C_{100}H_{160}S_{20}$ as the upper limit of the series. Physically this series is characterized by the decrease of distensibility, and the increase of rigidity, from the lower to the upper limit. Which term of the above series, that is, which degree of vulcanization is produced, is in every case only a function of temperature, time, and the proportion of sulphur present.

"As a chemical reaction the vulcanization process is not influenced by the physical state of the India-rubber colloid;

but the physical state of the India-rubber colloid while under vulcanization largely determines the physical constants of the vulcanization product."

From the above we conclude that dental vulcanite is essentially polyprene disulphide having the symbol $C_{10}H_{16}S_2$, which contains 32 per cent. of combined sulphur.

How to Vulcanize Rubber.—Having learned that rubber expands excessively in heating up to the vulcanizing temperature and shrinks during vulcanization; also that its induration is the result of a chemical combination of the polyprene and sulphur, and that a small amount of hydrogen sulphide may be formed, but that it is in nowise an essential factor of vulcanization; and further, that there is a diversity of opinion as to how rubber should be vulcanized, the author instituted the following experiments as a means for establishing a rational method for vulcanization:

A glass marble 31.5 mm. in diameter was ground so as to form two parallel flat surfaces 25 mm. apart. This was used as a model and flasked in a vulcanite flask with French's regular dental plaster. Five of these molds were made and excess spaces cut approximately three-sixteenths inch about the mold, but without gateway connections. No. 1 was filled with bow-spring (representative of the best rubbers) rubber, the flask closed and held firmly together in a Donham clamp (Fig. 102), and vulcanized under the Lewis gas regulator set at 320° F. for one hundred minutes. It was not removed from the vulcanizer until it normally cooled to room temperature. The flask had opened approximately an eighth of an inch. The specimen was sawed through the center of the flat surfaces and disclosed a dense rim of approximately 4 mm. thickness, a finely spongy interior, and emitted a strong odor of hydrogen sulphide. The cross-section measured 28.2 mm., that is, had increased in size 3.2 mm. Mold No. 2 was treated in every way the same as mold No. 1, except it was vulcanized for three hours. It presented the same general aspect except darker in color, and measured but 26.6 mm.; a shrinkage of 1.6 mm. (or one-half the amount of expansion, of No. 1) due to the eighty minutes' additional heat. Mold No. 3 was filled

in like manner, but bolted firmly together with three bolts, and subjected to heat the same as No. 1. The flat surfaces of Nos. 1 and 2 specimens were not distorted, while No. 3 was slightly convex. The plaster investment was more or less crushed and compressed, as shown by the surface of the rubber; the internal appearance was the same, but it had expanded to a diameter of 28.6 mm., showing great force in the expansion. Mold No. 4 was filled in like manner, tightly closed in a Donham clamp and vulcanized slowly; that is, the Lewis gas regulator was set at 280° F. for one hour, at 290° for forty minutes, and at 300° for two hours. The section of this specimen showed evenly dense vulcanization throughout its mass, but excessive shrinkage. At the periphery of the flat surface it measured 23.4 mm., and at the center 22.2 mm. Thus showing a difference of 6.4 mm. in thickness of the specimens, due to the methods of applying heat. Mold No. 5 was filled with two thicknesses of red rubber upon one side and the balance filled in with a good quality of plain pink rubber. This was placed in the Donham clamp and the Lewis regulator set at 320° F., for ninety minutes. There was slight excess rubber forced out, but no distortion of the flat surfaces. The section measured 25 mm., and showed but slight porosity at its center.

Fig. 98 shows graphically the model and five vulcanite specimens.

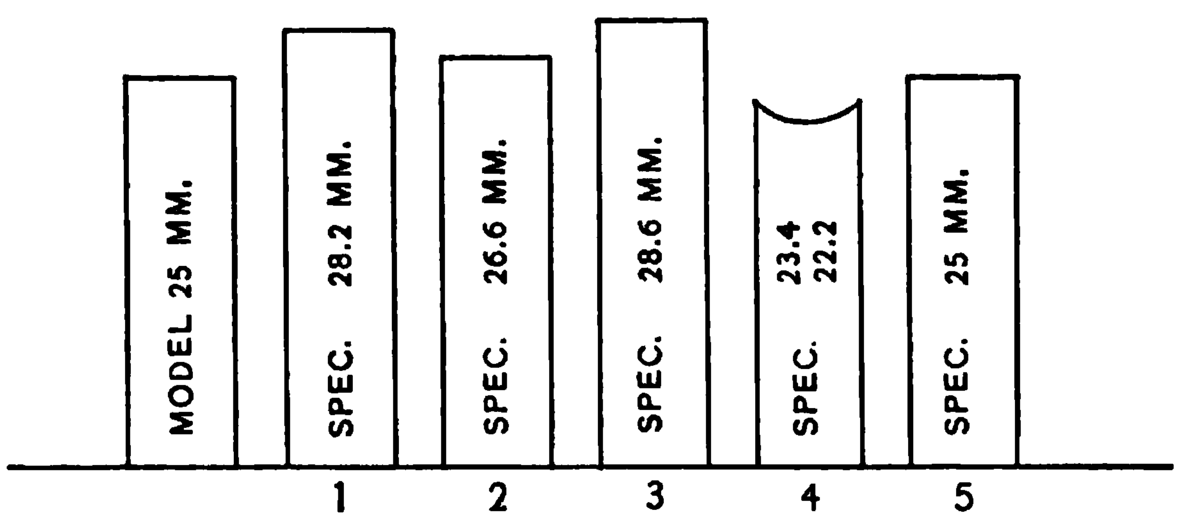

Fig. 98

The rationale of these experiments is arrived at by a study of the physical and chemical properties of the ingredients.

The essential constituents of dental rubber are caoutchouc and sulphur, both exceedingly poor conductors of heat, fusing between 239° F. and 250° F., and begins to combine chemically at 248° F. Both constituents expand excessively by heat, but their mixture begins to shrink with chemical union, and continues shrinking indefinitely under vulcanizing heat.

It is a physical law that: Force of expansion by heat is in the ratio to the denseness of the substance. Therefore the force of expansion of solids and liquids is very great while that of gaseous substances is comparatively small. It is evident that the small amount of hydrogen sulphide formed in the vulcanization cannot account for the great force generated, but that it is due to the expanding dental rubber; further, it is evident that it is not the expansion of the melted dental rubber, as chemical union and condensation begin with liquefaction; therefore perfect vulcanization requires a suitable control of the expanding dental rubber and the shrinkage in the forming vulcanite. (This cannot be accomplished in bolted flasks.)

The relatively large mass of rubber used in these experiments introduces no constant, but the magnitude makes the phenomena appreciable while a smaller mass would not be so readily comprehended. In these experiments (Nos. 1, 2, and 3) the surface of the rubber was rapidly raised to 320° F., causing the surface to expand and harden much in advance of that within. As the heat advanced more and more, expansion was taking place and a thicker and denser surface of vulcanite was forming until there was no more rubber to expand; and, as the forming vulcanite shrinks a vacuum must be created; because the internal melted dental rubber must contract in the direction of least resistance.

The finely porous condition within is undoubtedly due to the formation of H_2S. Why hydrogen sulphide should be formed is unknown to the writer, but it is quite possible the vacuum enabled the heat attained to decompose the hydrocarbon and the elements to combine with the sulphur

to the extent of filling nature's abhorred vacuum. At least it is an evidence, as Mr. Weber has said, that something has gone wrong. Mr. Weber, as previously quoted, has demonstrated that in vulcanizing highly refined rubber ingredients, under suitable conditions, no gas is formed. Further, the writer has demonstrated this fact by careful weighing before and after vulcanization, and found there was no loss of weight; whereas if a part of the substance had been dissipated as gas there would have been a loss of weight. Specimen 4 demonstrates that if the temperature is slowly raised to the high vulcanizing-point the resulting vulcanite will be dense and perfectly vulcanized throughout, but there will be excessive shrinkage. However, this does not prevent the expansion due to heating up, as both extreme specimens were subjected to the same heat during the expanding period. The low temperature of 280° F. permits but slight hardening of the rubber, and this throughout the entire mass, then raising the temperature 10° F. at a time permits a continuous even vulcanization with all the shrinkage toward the center; whereas in rapid vulcanization (specimens 1, 2, and 3), the shrinkage is toward the indurating peripheral portion. Specimen 5 introduces another constant, that is, dental rubber heavily loaded with oxide of zinc, fuller's earth, or other inert material.

These materials used in dental rubber as a color constituent act as a control of the properties of expansion, shrinkage, and contraction; however, these materials so reduce the strength of dental rubber that such rubber should never be used when strength is required. It should be used only as a facing and for bulk.

Summary for Practical Vulcanization.—1. A Spence plaster compound cast is necessary.

2. All wax model dentures should be reduced to the required thickness, and preferably encased in tinfoil.

3. The case should be flasked with a good dental plaster, excess space encircling the mold, but no gateways.

4. The flask being well warmed, but not above 212° F.,

is evenly packed with red or black rubber, or a combination of the two. In no place should the high-grade rubbers be more than 4 mm. in thickness (danger thickness). All space not filled with the not to exceed 4 mm. layer of red or black rubber is to be filled with pink rubber. A layer of pink rubber should be used over the labial and buccal surfaces for esthetic purposes.

5. The flask may be cautiously nearly closed under pressure, but the final closure is in the vulcanizer under the spring. Bolts and rigid flask presses are dangerous.

6. A spring should be used that will not permit of a pressure exceeding five hundred pounds, and also have a long range of resiliency. A volute form is best (Fig. 104).

7. Vulcanization should be in steam and at high temperature and short time, that is, the Lewis gas regulator should be set at 320° F. for one hour and twenty minutes. As the heating qualities of the gas of various cities fluctuate, the time element must be determined by each operator for himself. However, sufficient heat should be applied to reach the maximum temperature in approximately twenty-five minutes, not varying more than five minutes either way; then the high heat should be maintained until the rubber, where not more than 1 mm. in thickness, is very elastic, but hard enough to readily take a high polish. This result will be accomplished in many offices in one hour and twenty minutes, that is, twenty-five minutes to heat up to 320° F. and held at that temperature fifty-five minutes which make the one hour and twenty minutes; other laboratories will require a longer or shorter time.

The reason for the elastic spring and short time method of vulcanization is: The expansion cannot be controlled as to its amount, because it must reach its maximum of expansion before induration can begin. The effect of the expansion is influenced by the method of retention by bolts or by spring clamps, and whether vents are or are not provided.

The amount of shrinkage is very much influenced by time; the longer the time the dental rubber is subjected

to vulcanizing heat, the greater the amount of shrinkage. High heat causes rapid hardening of the surface, and the internal pressure during the hardening and shrinking of the surface causes a close adaptation of the vulcanite to the sides of the mold and teeth; then as the internal shrinkage takes place it will be toward the hardened surface. By the use of a flexible spring the expansion is controlled so that it cannot do harm, and if sufficient expansion has taken place to open the flask the spring will permit outflowing of sufficient rubber to reduce the internal pressure to the power of the spring. Whereas if bolts and gateways were used the expansion forces out a part of the rubber until there is no internal pressure, and when shrinkage takes place there cannot be enough material to fill the mold. Therefore rubber tightly shut in the flask, with its expansion and shrinkage controlled by a suitable spring, and rapid surface hardening, due to the high heat (320° F.) at the surface and a decreasing degree of heat toward the center of the mass of rubber because of its poor conductivity, is the logical and scientific method of vulcanizing all dental rubber. However, this method is best adapted to comparatively thin masses of rubber; all thick places in vulcanite appliances should be filled with an indifferent material, therefore such places are filled with plain pink or white rubber.

If the flask is to be bolted, then gateways opening into vent spaces are imperative. Also the pink rubber is even more important than when vulcanizing under a flexible spring. If bolts are used the flask should be completely closed before the flask is placed in the vulcanizer. This closing of the flask is probably more safely done in boiling water; whereas by the elastic-spring method it is not necessary that the flask shall be entirely closed. The plaster in the flask should be kept out of water, and therefore will have much more resistance to the pressure of the expanding rubber and to the force of the spring. There should be from two to five ounces of water in the vulcanizer. A support may be placed in vulcanizer upon which the flasks rest, or if the volute spring is used the spring is placed as shown in Fig. 104.

DR. SNOW'S LATE RESEARCH IN THE SHRINKAGE OF RUBBER IN VULCANIZATION.

A close study of Dr. Snow's experimental work will richly repay the student, for a comprehensive knowledge of the shrinkage of rubber in vulcanization is most valuable. It also suggests the philosophy for the improved method and implements for vulcanization to be presented farther over in this chapter.

Fig. 99 is a schematic diagram of the testing vulcanizing flask.

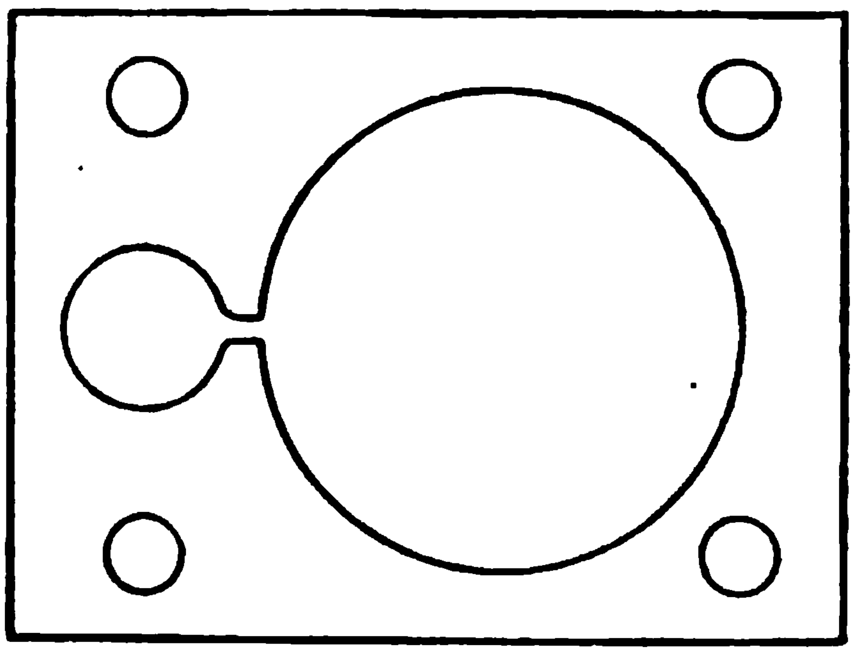

FIG. 99

Explanations.—All weights in this table are in grams. All bulks in cubic centimeters (see p. 216).

All samples were vulcanized at 75 pounds by the steam gauge, it being the same as 300° F. by the mercury bath thermometer, or 320° actual temperature.

Columns 3 and 7 show the weight and also the bulk of water equivalent to the respective samples; as a cubic centimeter of water weighs 1 gram.

All the vulcanizing was done in the same brass mold, which was closed by bolts without springs, and had a gateway leading to an overflow chamber, which received the rubber expelled from the mold as it was heated from 212° F. to the vulcanizing point. The capacity of mold at 70° F., 10.710 c.c. At 212°, 10.759 c.c. At 320°, (75 pounds pressure) 10.796 c.c.

The discrepancies between columns 1 and 5 are due to the absorption of a small quantity of water by the rubber when vulcanizing; showing that vulcanite is slightly porous. The amount of water absorbed is about half a drop for a sheet of rubber. Rubber compound does not lose weight by vulcanizing.

Column 11 denotes the weight of rubber expelled from the mold as the sample is heated from 212° to the vulcanizing point. Column 12 shows the bulk of the same.

In column 13 the shrinkage, shown in column 9, which is the difference between columns 3 and 7, is added to the overflow, column 12, and shows the total amount of deficiency of vulcanite in the mold when the vulcanizing process was completed. Column 14 gives the percentage of this deficiency. It will be noted that the deficiency is greater in the dark-colored rubbers and less in the lighter-colored ones, the light rubbers containing more foreign matter in their composition.

Conclusions.—If the flask is bolted and gateways provided for the free escape of the rubber as it is heated, the deficiencies shown in columns 13 and 14 are inevitable, and the denture will always be defective.

If spring pressure is applied to close the flask, and the rubber is confined so that none of it can escape unless the parts of the flask are separated by its expansion, the deficiency will be less than that shown in columns 13 and 14; the amount depending upon the average thickness of rubber in the case.

To produce the best results, spring pressure must be used to close the flask, the mold must contain an excess of from 3 to 5 per cent. of rubber when vulcanizing commences, and the flask must, therefore, not be entirely closed at this time. Its closing must be effected gradually by spring pressure and after the vulcanizing process has progressed far enough to cause a partial shrinkage of the rubber. For vulcanizers of the ordinary type this may be accomplished by two vulcanizations.

TABLE SHOWING THE BEHAVIOR OF DIFFERENT RUBBER COMPOUNDS IN VULCANIZING

BY DR. GEORGE B. SNOW

	Weight unvulcanized.	Weight in water, unvulcanized.	Displacement in grams and cubic centimeters.	Specific gravity, unvulcanized.	Weight vulcanized.	Weight in water, vulcanized.	Displacement in grams and cubic centimeters.	Specific gravity, vulcanized.	Shrinkage, cubic centimeters.	Percentage of shrinkage.	Overflow, weight.	Overflow, bulk, cubic centimeters.	Deficiency in bulk, cubic centimeters.	Percentage of deficiency; bulk.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
McCormick:														
Light Pink	28.247	17.872	10.375	2.723	28.240	18.197	10.043	2.812	.332	.032	.865	.308	.640	.062
Ordinary Black . . .	11.380	1.155	10.225	1.113	11.393	1.678	9.715	1.173	.510	.050	.625	.533	1.043	.102
Maroon	17.235	6.965	10.270	1.678	17.263	7.502	9.761	1.768	.509	.049	.891	.503	1.012	.099
Light Red	17.321	7.009	10.312	1.680	17.347	7.478	9.869	1.758	.443	.042	.876	.498	.941	.091
S. S. White:														
Maroon	18.165	7.912	10.253	1.771	18.18	8.38	9.8	1.845	.453	.044	.708	.384	.837	.082
Gold Base	16.417	6.091	10.326	1.589	16.437	6.539	9.898	1.66	.428	.041	.633	.381	.809	.078
No. 1 Red	21.595	11.302	10.293	2.098	21.602	11.725	9.877	2.187	.416	.040	1.036	.474	.890	.086
Doherty:														
Maroon	15.821	5.526	10.295	1.538	15.837	6.040	9.797	1.616	.498	.048	.924	.572	1.070	.104
No. 1 Red	17.368	7.162	10.206	1.702	17.379	7.627	9.752	1.782	.454	.044	.802	.450	.904	.089
Samson	14.545	4.34	10.205	1.425	14.569	4.864	9.705	1.501	.500	.049	.792	.528	1.028	.101
Traun:														
Gold Dust	11.498	1.272	10.226	1.124	11.517	1.764	9.753	1.181	.473	.046	.582	.493	.966	.094
Ash's:														
Dark Elastic . . .	13.200	2.730	10.470	1.261	13.220	3.547	9.673	1.366	.797	.076	.579	.424	1.221	.117

ADVANTAGES AND DISADVANTAGES OF VULCANITE AS A BASE FOR ARTIFICIAL DENTURES.

Advantages.—1. It is easy of manipulation; it can be molded into any form, and it becomes, upon proper vulcanization, very strong, tough, flexible, and elastic. It is repaired with equal ease.

2. It is the lightest of all substances used in the mouth; its specific gravity is from 1.15 to 1.75, while aluminum, the lightest metal suitable for use in the mouth, has a specific gravity of from 2.5 to 2.7.

3. It is inexpensive, both as to cost of material and labor in construction, thus bringing it within the reach of patients unable to afford metal plates.

4. There is no material with which contours and difficult cases can be so easily and perfectly restored.

Disadvantages.—1. It is a very poor conductor. It prevents the proper radiation of heat from the mucous membrane over which it is placed, thereby leading to excessive resorption of the hard tissue and lowering the vitality of the soft tissue, in consequence of which they are more subject to the action of irritants.

2. The physical property of continued shrinkage under vulcanizing heat is certainly a disadvantage, because it interferes with perfect adaptation when revulcanized.

By some vulcanite is considered as porous. This is undoubtedly an error. In 1869 a committee of the Pennsylvania College of Dental Surgery, consisting of Professors Wildman, Buckingham and Truman, were appointed to investigate and report upon dental vulcanite. In part the report states: "In repeated examinations made to test this (porosity), by high power of the microscope, nothing resembling pores has ever presented. It has been found impossible to procure a section thin enough, to transmit light, although ground to extreme tenuity. Examined as an opaque object, it presents a homogeneous mass, with no appearance of openings for the admission of fluids; nor have we ever been able to discover moisture in specimens that have been worn. That it is impenetrable to moisture

in the ordinary process of wear, is apparent in the non-increase of weight." In correspondence with Professor Truman since the first edition of this book, he writes, that he has had no evidence to change the conclusion as presented in the report published in the *Dental Times* of July, 1869. Further than this, the process of manufacture of rubber requires compression between very powerful rollers, and its physical property of increasing the specific gravity by vulcanization would favor great denseness.

This paragraph is at variance with the recent investigations of Dr. Snow. However, it must be recognized that both findings were by the highest and most painstaking authorities; therefore, it is reasonable to suppose that the difference is in the gums or in the dyes and fillers used fifty years ago and now.

Red and pink rubbers are considered injurious because of their coloring matter, vermilion (mercuric sulphide). This criticism is unjust, because pure mercuric sulphide is insoluble in water, alcohol, alkali, and all acids except nitrohydrochloric acid, which under no condition should come in contact with red or pink vulcanite, as this acid converts HgS into $HgCl_2$ (corrosive sublimate). It is evident that the heat of the vulcanizer cannot decompose vermilion because in its manufacture the ingredients are subjected for many hours to a temperature approximating 1200° F.; therefore it would be unreasonable to expect a temperature under 400° F. to undo the work of three times as great a heat. However, it is possible that free mercury may be in red rubber, but if so it is because it was placed there in a poor quality of vermilion; therefore the dentist should use only the high-grade rubbers of reliable manufacturers.

INSTRUMENTS AND APPLIANCES USED IN VULCANITE WORK.

Wax Spatulas.—These are instruments used in manipulating wax. There are different types of these instruments, as carvers, ironers, knives, and spoons. Carvers are small

knives and scrapers. Nos. 1 and 2 of the Evans set are of this class (Fig. 100). (The No. 3 of this set is a burnisher for tinfoil.) Ironers have sufficient bulk of metal in their ends to convey heat to the wax. They are of various forms designed to facilitate the work. Fig. 101 shows a number of these instruments. Knives are larger than

Fig. 100

the knife-shaped carver and are designed for coarser work. Spoons are for melting and carrying wax. These various classes are often combined in double-end instruments, especially so with the knife and spoon (Fig. 102).

Flasks.—There are a great many varieties of vulcanite flasks upon the market. They are made of iron or brass.

Iron has the greater affinity for oxygen and sulphur in vulcanizing, but retain their adjustment and form much better than brass. The brass flasks are the more easily cleaned. Each time the flasks are used they should be thoroughly cleaned with a stiff brush and sapolio.

Fig. 101

The Star flask is one of the oldest forms, and, being reversible, is probably adapted to more cases than any other (Fig. 103). The Wilson flask is characterized by a very narrow rim upon the lower section, with a correspondingly

wide rim in the upper section. It is designed to be used for full cases only, and with a clamp and spring (Fig. 104). Fig. 104 shows a two-flask Donham clamp with a Wilson volute spring[1] below and a Wilson flask above. The Whitney

Fig. 102

[1] The author has perfected a suitable volute spring. It is placed upon the market by the Cleveland Dental Mfg. Co. It is not patented and the inventor receives no financial benefit from it; therefore address all letters of inquiry to the manufacturers. The spring is so formed and tempered that each $\frac{1}{8}$ inch compression produces approximately 100 pounds' pressure. The large end should always be placed against the flask.

flask is very much used. There are two sizes, the larger being five-sixteenths of an inch deeper than the smaller.

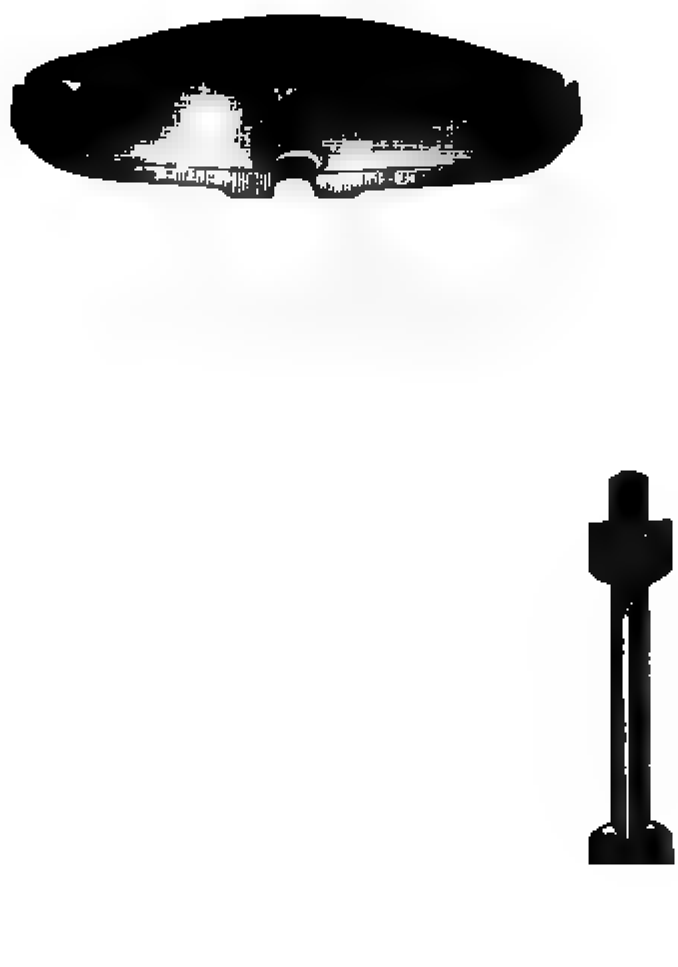

FIG. 103

Fig. 104

Fig. 105

Fig. 106

Fig. 105 shows the regular size with springs upon the bolts to aid in closing the flask.

The box flask is designed for interdental splints and any extra large pieces of vulcanite. It is made in two sizes, one as large as can be used in a two-flask vulcanizer and the other for the three-flask vulcanizer (Fig. 106).

Flask Presses.—The flask press (Fig. 107) is an indispensable appliance in a well-equipped laboratory, and yet probably its improper use has caused more misfit vulcanite dentures than all other causes. When the principles involved in the flask press and its use are understood, there should be no trouble in handling it.

Fig. 107

All plasters expand and are compressible, some excessively so. French's regular dental plaster is the best and most commonly used by the profession; so these statements are in connection with this plaster. A molar tooth one-half

inch in diameter under a thousand pounds' pressure would be driven into well-set plaster one-twentieth of an inch. Rubber when cold is very tenacious and will resist a very heavy pressure for a short time, but will gradually yield. Plaster compresses to its full extent in a very few seconds. It is easy to comprehend that if an excess of rubber is placed over the teeth upon one side, and heavy pressure is applied, the teeth will be driven into the plaster encasement and consequently the teeth upon that side of the denture will be too long. It can also be comprehended that if the cast is formed of regular plaster, and excessive rubber and pressure be applied to the vault of the cast, it will be pressed upward and the plate warped.

We shall now consider the power of the press. The screw is a combination of the lever and wedge, and its power is calculated by multiplying the circumference described by the lever by the pitch of the screw. A press having a handle 8 inches long would describe a circumference of 25+ inches. There are ten threads to the inch, hence a pitch of $\frac{1}{10}$ of an inch. An allowance must be made for friction in the screw, but $\frac{1}{5}$ will be very liberal, when we shall have, for every pound of force applied at the end of the handle, two hundred pounds' pressure under the screw, or a ton for every ten pounds of force. If the force is applied nearer the middle of the handle it will produce approximately one-half as much pressure or a ton for every twenty pounds of force. It is now easily understood why plates are warped and these heavy malleable-iron presses are sometimes broken.

At the request of the author the Cleveland Dental Mfg. Co. have added a volute spring to their flask press (see Fig. 107). This provides an element of safety to this dangerous implement, and creates a follow-up pressure which is absent in a rigid press.

Vulcanizers.—There are in use at the present time many forms of vulcanizers. It is unnecessary to enumerate them. The description will therefore be confined to one of the best examples of the somewhat extensive list.

The Lewis Cross-bar Vulcanizer (Fig. 108) embodies many valuable improvements, and is probably one of the strongest,

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safest, and most convenient vulcanizers of the cross-bar pattern in use.

The boiler is hand-made from copper, rolled expressly for this form of vulcanizer, and is of unusual thickness. The cap is ribbed on the under side to resist any strain which may be put upon it. This cap has but two holes drilled

Fig. 108

in it: one for the mercury bath, to which the thermometer is attached; the other for the "manifold," which carries the safety valve, blow-off, gas regulator, or steam gauge (Fig. 109). The ring surrounding the boiler is of cast steel, and is therefore of ample strength. Besides the lugs for taking the strain off the cross-bar and bolt, it has a dovetailed projection for the insertion of a lifting handle.

It will be observed that when the cross-bar and cap are removed, there are no swinging bolts or attachments to the pot.

The cross-bar is of an improved form, and is made of cast steel. One end is at right angles to the main bar, and terminates in projections which catch under the lugs on the ring. Over the projections is a small rib which prevents the bar from dropping out of position. The other end of the cross-bar has an enlarged portion for the reception of the bolt, and is terminated by a handle.

Fig. 109

The vulcanizer is closed by one bolt suspended in a slot on the hand-end of the cross-bar. The bolt is squared to prevent rotation, and is surrounded by a spring for the purpose of disengaging it from the lugs when the nut is loosened, and for always retaining the bolt perpendicularly and forcing it in place automatically.

The vulcanizer is opened by loosening the nut on the bolt by means of the wrench furnished for the purpose. The bolt will be forced downward through the action of the spring. The handle of the cross-bar is then seized, and with the thumb against the nut it is pressed until the bottom of

the bolt is disengaged from the lugs, when the bar may be lifted (Fig. 110).

Fig. 110

INSTRUCTIONS FOR THE USE OF GAS AND TIME REGULATORS.

"The gas regulator (Fig. 111) is secured to the cap by means of the short iron pipe or coil. This is screwed into a hole drilled through the cap of the vulcanizer, and tapped with a 'one-eighth gas-pipe tap.' If the vulcanizer has a 'Lewis manifold' attached to the cap of the vulcanizer, remove the screw between the blow-off and safety valve and screw the coil pipe in its place. After the gas regulator has been properly fitted, place the vulcanizer in the jacket and in the position in which it is to be used. Connections between the time regulator, gas regulator, and gas burner are made by means of rubber tubing. The engraving (Fig. 112) illustrates the correct method of connecting gas and time regulators to vulcanizers. Cut a piece of tubing of

sufficient length to reach from the gas-supply tap to the *time regulator*, and connect them; cut off another piece to reach from the time regulator to the *gas regulator*, and attach to the gas regulator by the *upright* or straight nipple on top of the No. 4 Lewis gas regulator; then connect the downward curved tube of the gas regulator to the gas burner under the vulcanizer with another piece of rubber tubing.

Fig. 111

"The time regulator is more convenient when placed on a bracket near the gas-supply pipe. It is then out of the way, and not likely to be broken from contact with tools, and can also be used as a timepiece.

"**To Set the Time Regulator.**—When the valve lever on top of the time regulator (Fig. 112) is engaged with the screw

upon the minute arbor on the back of the clock, the valve is held open for a length of time depending upon whether the lever is engaged with the first, second, or third thread

Fig. 112

of the screw; and the lever will be cast off and the valve closed when the minute hand reaches the figure XII. When the minute hand is at IX the lever will be cast off at the end of fifteen minutes, if it is engaged with the *first* thread

of the screw from the end; an hour and a quarter, if engaged with the *second* thread, and so on. A trial should be made, and the time ascertained which is necessary for heating the vulcanizer to the vulcanizing-point, and this time should be added to the proposed time for vulcanizing. We have, therefore, the following:

"**Rule.**—Turn the minute hand to as many minutes *before the hour* as the number of odd minutes desired; then put the end of the lever in the threads of the screw upon the minute arbor at the back of the clock. The *first* thread from the end gives the odd minutes to which the clock is set; the *next* and *each* succeeding thread gives a full hour. For example: For an hour and twenty minutes, set the minute hand at the figure VIII, and engage the lever in the *second* thread from the end of the screw. At the end of that time the lever will disengage and automatically shut off the gas from the vulcanizer. If this were to be an hour longer—*i. e.*, two hours and twenty minutes—the lever should be placed on the third thread of the screw. For three hours, set the minute hand at XII and engage the lever in the third groove of the screw.

"**Steam Pressure.**—Those who use vulcanizers should be thoroughly informed as to the nature and properties of steam. The fact should be borne in mind that a vulcanizer is subject to the same laws and conditions as a steam boiler, which it is in fact, and although it is comparatively safe and easily operated, it may, by carelessness or ignorance in its management, become exceedingly dangerous.

"The following table of steam pressure will be found convenient for reference, as it has been corrected so that it shows the true temperature for any pressure indicated by the steam gauge. Fractions are omitted, and the nearest whole number is used instead. The French table generally used shows 14.7 pounds pressure at 212°, whereas the steam gauge at that temperature will indicate 0, unless by the expansion of heated air confined in the vulcanizer. The gauge is therefore just *one atmosphere* lower than the French table:

TABLE OF THE ELASTIC FORCE OF STEAM[1] (CORRECTED TO CORRESPOND WITH THE STEAM GAUGE).

Degrees of temperature, Fahrenheit.	Elastic force in pounds per square inch.
212	0
220	2
230	6
240	10
250	15
260	21
270	27
280	34
290	43
300	52
310	63
320	75
330	89
340	104
350	120
360	140
370	160
380	180
390	205
400	234
410	264
420	296
430	335
440	375
450	415
460	455
470	515
480	565
490	603
500	663
510	721
520	793
530	864
540	937
550	1015

"It will be noticed that as the temperature rises the pressure of steam increases in constantly increasing ratio for equal increments of heat, the pressure being nearly doubled by the addition of 50° to the temperature. This fact will show the *necessity* of care and watchfulness while vulcanizing.

"The bulb of the thermometer is set in a mercury bath. This is the small cup, forming a part of the vulcanizer cap,

[1] General instructions for operating dental vulcanizers, Buffalo Dental Manufacturing Co., July, 1898.

to which the thermometer case is screwed. This cup should contain sufficient mercury to insure its touching the bulb of the tube when the thermometer case is screwed down properly. This makes a *metallic connection* between the thermometer bulb and the vulcanizer cap, and is *absolutely necessary* for proper indication of heat by the thermometer.

"Should the mercury column separate, it can usually be reunited by removing the tube from the thermometer case, holding it perpendicularly, and striking the bulb with some force upon the palm of the hand, or by holding the tube by the bulb and giving it a sudden flirt. If the vulcanizer is used with the thermometer in this condition, it should be remembered that it is the *whole column* that denotes the heat, and allowance should be made for the broken part, *i. e.*, if there is enough mercury separated to fill the space of 10°, the remainder of the column should only rise to 10° less than the temperature desired.

"Directions for inserting a new tube in the thermometer case will generally be found on the package containing the tube and scale.

"Thermometers are accurately marked, by test instruments, at the 212° and 320° points, and the scales are especially graduated for each tube, as the positions of the points above named vary in different tubes. *Each tube must therefore be used with its own scale*, and in fitting it to the case care should be taken that the black mark on the tube indicating the 320° point is brought exactly opposite to the 320° point on the scale.

"The thermometer does not always give a correct indication of the heat of the vulcanizer. It only gives the temperature of the vulcanizer top, which may not be that of the flask. In fact, the indications of the thermometers employed on vulcanizers are almost invariably too low, owing to imperfect conduction of heat, radiation, etc.; and the vulcanization temperature, instead of being 320°, as indicated, is more usually 330° to 340°."

The plan of providing a mercury bath for the reception of the bulb is a great improvement over the old way, and prevents the fracture of the bulb by the great pressure of

the steam, which was of such frequent occurrence when the thermometer was in direct contact with the latter.

Damage to the glass bulb of the thermometer is manifested by a rise in the mercury, which cannot be brought down to the usual vulcanizing-point by turning off the flame of the burner; consequently the thermometer ceases to correctly indicate the degree of heat, and imperfect vulcanization is the result. Leakage of steam around the packing of the vulcanizer should also be guarded against, as in such cases all of the water may escape from the apparatus before the vulcanizing is complete. Loss of all of the water in the vulcanizer may be detected by a persistent fall of the mercury, even when the gas flame is greatly increased, and when this phenomenon is observed the gas should be turned off, the vulcanizer allowed to cool, and new packing adjusted. Failure to strictly observe this rule has undoubtedly resulted in many serious accidents.

Fig. 113

Vulcanizing.—The flask or flasks are placed in the vulcanizer and filled about 1 inch deep with clean water. The packing should be without a break in its continuity, otherwise the steam will escape; the joint between the pot and cover must be protected from adhesion by slightly coating it with black lead or soapstone. The cover is then put on, but the valve is not closed until the heated air which precedes the generation of steam has escaped; the valve is then closed. A close watch must be kept on the thermometer or gauge until the vulcanizing point is reached, unless a time regulator is used.

Flask-tongs.—Fig. 113 shows a useful form of flask-tongs for lifting flasks from the vulcanizer. They are made of

Fig. 114

sufficient length to reach the bottom of a three-case vulcanizer, and will securely grip the flask.

Files.—Fig. 114 illustrates some excellent forms.

Vulcanite Trimmers.—There are a great variety of scrapers and chisels from which each operator may select such as seem best adapted to his hand. The writer's preferences are the ones here illustrated (Fig. 115).

Fig. 115

GRINDING AND POLISHING.

In the construction of artificial dentures upon any base, grinding and polishing are very important operations and

require efficient equipment for their accomplishment. For this purpose a small lathe of suitable construction is necessary. These lathes will require approximately one-sixth horse-power, which may be provided by either electricity, water, steam, or the foot. The desirability of the power chosen is in the order named. However, steam is rarely used in a dental office because of the expense of installing and maintenance. There are many patterns of these implements from which the dentist may select. There are two general principles involved in all of these appliances: (1) the motor and lathe are combined as one implement; (2) the motor and lathe are separate and coupled together with a band or cord.

Fig. 116

The electric current is most convenient and serviceable when it can be had in the office. Fig. 116 represents an apparatus of the first type, that is, motor and lathe combined. This electric lathe is admirably adapted to general laboratory uses or as an operating-room lathe. Its bearings are completely protected from dust. It is noiseless, and is constructed with such precision that its motion is hardly perceptible. It is adapted to the 110-volt direct current, and has sufficient power for all purposes required by the dentist. It requires no special table, hence can be placed in any position at the convenience of the operator. It has a range of speed varying from 1000 to 4000 revolutions per minute. The regulation of the speed and starting and stopping of the lathe are effected by the milled stud. The

chucks are held upon the shaft of the motor by friction, and can be removed while the motor is in motion or stationary by turning the milled nuts near the ends of the shaft. These motors can be obtained for other voltages and for the alternating current.

Fig. 117 is a lathe of the second type, and can be operated by any power through a cord. This illustration shows a convenient arrangement of lathe and foot power.

Fig. 117

These lathes are all provided with various forms of chucks for grinding stones, buffers, and polishing brushes. Figs. 116 and 117 each show a stone-mounted chuck upon one end of the shaft, and the tapered-screw-cut spindle for buffers and polishing brushes at the other end.

Most makers of lathes furnish an extra clutch chuck for

burring engine instruments. Fig. 118 shows an additional nut the author has had added to the clutch chuck for his

Fig. 118

Fig. 119

Fig. 120

lathe. By this means a three by one-half inch carborundum stone is mounted. The figure also shows an engine mandrel mounted with a small stone in the clutch. The author has

no use for any other stone chuck, and no changes are required except in the small stones, burs, and bits used in the chuck. Fig. 119 is the "Ideal Emery Cloth Arbor," put upon the market by Samuel A. Crocker & Co., Cincinnati. This is an especially useful addition to the lathe for vulcanite work.

The lathe should be kept clean, well oiled, and true running. Grinding is a very important accomplishment—indeed, it may be called a fine art in mechanical dentistry—and can be acquired only by technical training and the use of true-running and well-cared-for equipment. Next to the lathe running true, the stone must be kept true and sharp; this is accomplished by the use of a machinist's emery-stone dresser (Fig. 120). This tool is used over a firm support, with a moderate pressure, upon the rapidly revolving stone. It not only produces a true surface, but a very sharp-cutting one. The tool should be applied often.

Stones.—The stones used in the dental laboratory are made of either corundum or carborundum.

Corundum is a mineral found in Ceylon, and in Pennsylvania, Georgia, Massachusetts, and North Carolina. It occurs in crystals of the form of double six-sided pyramids of various sizes, and in some localities in large masses without crystalline form. Corundum is an aluminum oxide having a formula Al_2O_3. Emery, the use of which preceded corundum as an abrasive agent in the dental laboratory, is a coarse variety of corundum. Corundum is prepared for use by crushing in an iron mortar. The required size grit is mixed with finely ground shellac in the proportion of 3 ounces of corundum to 1 of shellac, and formed in iron molds by the aid of heat and pressure. The surface shellac is dissolved out with alcohol, leaving the abrasive crystals exposed. Wheels made of corundum require to be run wet, otherwise the frictional heat will draw the softened shellac bond to the surface, producing a glaze which is non-abrading

Carborundum is a manufactured grit; it is harder and more brittle than corundum, and is next to the diamond as an abradant. Carborundum was made experimentally in 1893 by Mr. G. E. Acheson, and is now manufactured on an extensive scale at Niagara Falls. It is made of a mixture of

finely divided coke, pure silica sand, sawdust, and salt (NaCl). Ten tons of this mixture is placed in a furnace 16 feet long by 6 feet wide and 8 feet high. Electrodes are connected at the center of each end with a core of crushed coke. About 1000 horse-power of energy is utilized at an average voltage of 185, reaching a temperature approximating 7500° F. The salt acts as a flux. The sawdust burns out, leaving the mass porous for the escape of gases. The current is applied for thirty-six hours; it is then withdrawn and the mass given time to cool. About two tons

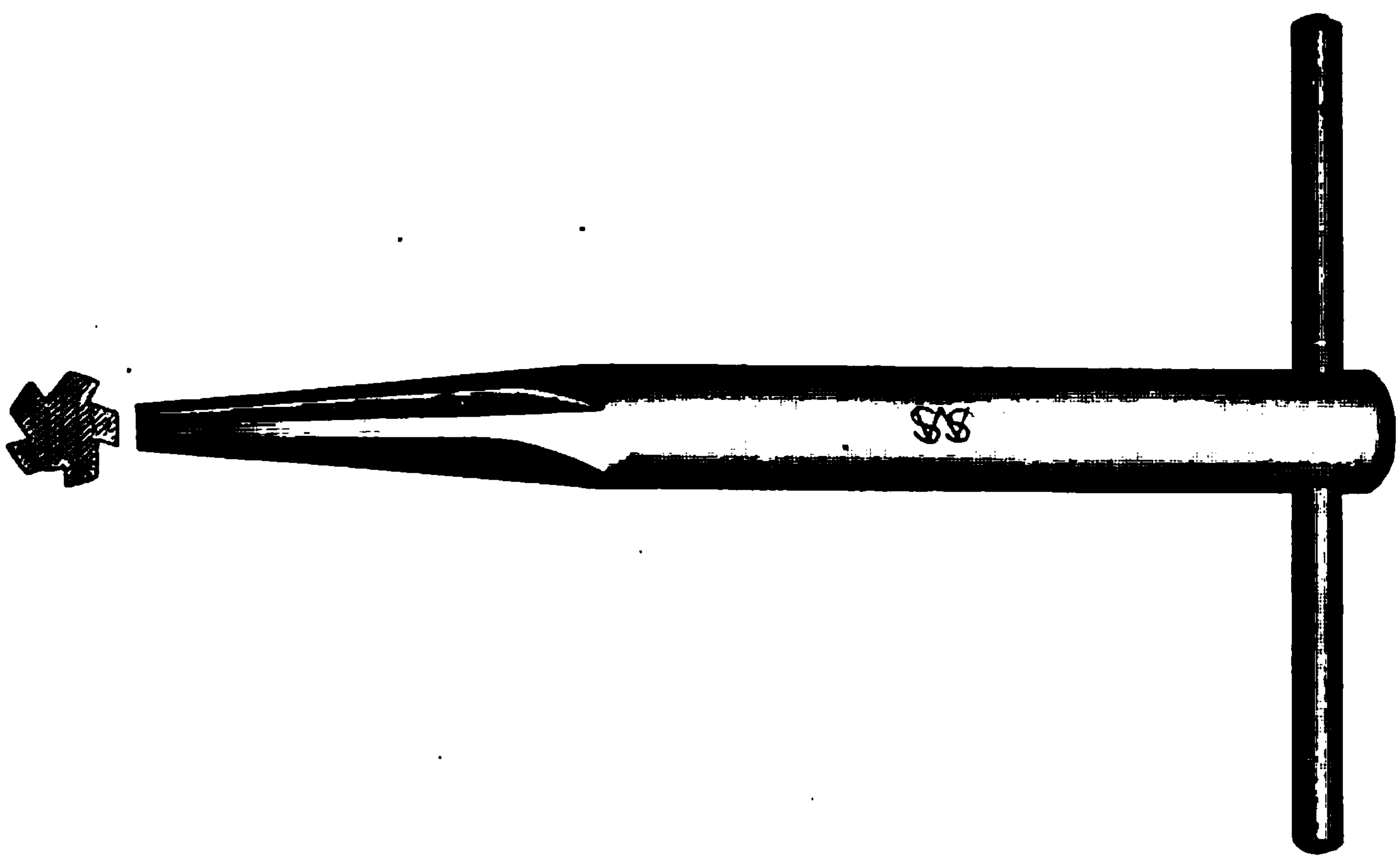

FIG. 121

of crystals are formed about the core, consisting of the carbide of silicon (CSi). These crystals are crushed, washed, and sieved, mixed with feldspar and clay as a bond, molded into shape under heavy pressure, and burned in a kiln for several days. Wheels made of carborundum may be run either wet or dry. It is claimed for them that they do not clog; however, the surface becomes so filled with dust that they are not nearly so effective as when tooled as previously described. The wheels have a tendency to wear untrue, probably due to imperfections in the mixing with the bond and burning in the kiln. Frequent tooling overcomes this

defect and keeps them true and sharp until they are worn out.

Buffers.—Buffing wheels and cones are used on the thread-cut spindle in finishing the denture; they carry fine abradants and remove small defects and scratches from the surface of the work. They are made of various materials, as felt, cotton duck, leather, soft wood, cork, and disks of cloth or chamois leather stitched together. Felt is probably the best and most commonly used material for dental buffers. The wheels are made in various sizes and shapes. A wheel two or two and one-half inches in diameter and one-half-inch thick is an excellent size. Knife-edge wheels are very useful in some places, but they must be properly used or they will quickly cut a groove. They also wear away rapidly, thus destroying the knife-edge effect. They require frequent tooling with a knife or chisel to keep them turned to an edge.

Brushes.—Brush wheels, both stiff and soft, are used. These wheels are made in various forms. Their wooden centers, which are straight drilled, should be reamed to a taper. Fig. 121 shows a suitable reamer. They are used on the threaded taper spindle. The bristles are either straight, converging, or diverging. The stiff converging wheel is excellent for carrying the abradant between the teeth where the felt cannot reach. The soft-bristle brush is used to carry the finest abradant and produces the gloss.

Finishing Powders for Vulcanite.—Pulverized pumice stone for buffing and prepared chalk for glossing are especially suited to vulcanite work.

Pumice stone is volcanic scoria or lava. Chalk is calcium carbonate, a soft variety of limestone; it is prepared by freeing it from particles of coarser grit.

Use of Stones.—The stones are used to grind the porcelain teeth, sharpen instruments, etc. It is safer to run the stone at a low speed. There is danger of chipping and checking the porcelain by the pounding of an untrue stone and heat produced by a clogged one. If the stone is true and clean, and the tooth held with light pressure, it will be rapidly cut with hardly perceptible frictional heat, consequently no

chipping or crazing of the porcelain. By the same care a steel instrument may be ground without drawing its temper as indicated by the blue color and spoiled cutting edge. A higher speed may be used, but greater care is required.

Buffing.—The buffing is done by first using the large felt wheel and pulverized pumice stone. The work, the felt, and the pumice must be kept thoroughly wet, otherwise sufficient frictional heat may be generated to roughen the vulcanite and possibly warp the denture. It should be obvious to the student that if the work is held at one place against the felt carrying an abradant a depression will be cut into its surface. Hence the work while being held against the buffer must be kept in constant motion. This motion should be a steady systematic procedure, not of a jerky, indecisive type. The denture should be finished with true symmetrical convex or concave surfaces in keeping with the conformation of the part. Facets show either inexperienced or careless buffing. The buffer may be run at high speed, in which case the work must be held with moderate pressure only against the buffer. Usually it is safer to use a moderate speed and greater pressure, and in some places it is wise to use the lowest speed and light pressure. The buffer does not cut of itself, but it carries and applies the abradant; therefore the efficiency of the buffer is largely due to the manner in which the abradant is applied. The abradant, saturated with water to the consistency of soft mud, is applied to the surface to be buffed and the farther edge is placed against the well-moistened buffer. The buffer engages a small amount of the abradant and carries it over the surface of the work. As the buffer wheel rises from the surface of the work, it throws off a portion of the abradant, but a small portion is imbedded in the surface of the buffer to be again carried over the surface of the work. As the work is pushed forward, more abradant is engaged and made to serve its purpose. The work is given a sideways movement as well as a forward one until all of the abradant is removed from the surface of the work. More abradant is applied and the operation repeated until the work is suitably finished. If the buffer

is applied to the nearer edge of the abradant and the work drawn forward the buffer will push away the abradant, of which only that portion adhering to the buffer and making the complete circuit will be effective. This method is wasteful of abradant, time, and energy.

Glossing.—The glossing is done with the rapidly revolving soft-brush wheel and the prepared chalk. The chalk well moistened with water or alcohol is applied to the surface of the work and held lightly against the brush wheel. As in buffing, the work is pushed against the brush. With the beginning of glossing the brush wheel is moistened, but later is run dry. Alcohol is the preferred moistener for the glossing powder because it serves to attach the powder to the work and quickly evaporates, leaving the powder in a dry condition, best for glossing.

HEAT.

In vulcanite work heat is required for warming wax, rubber, flasks, and converting the rubber into vulcanite.

Fig. 122

Bunsen Burner.—For all these operations the blue or Bunsen flame only is suitable. Fig. 122 shows a Bunsen

burner designed for the laboratory bench and connected to the gas cock with rubber tubing. Fig. 123 shows a

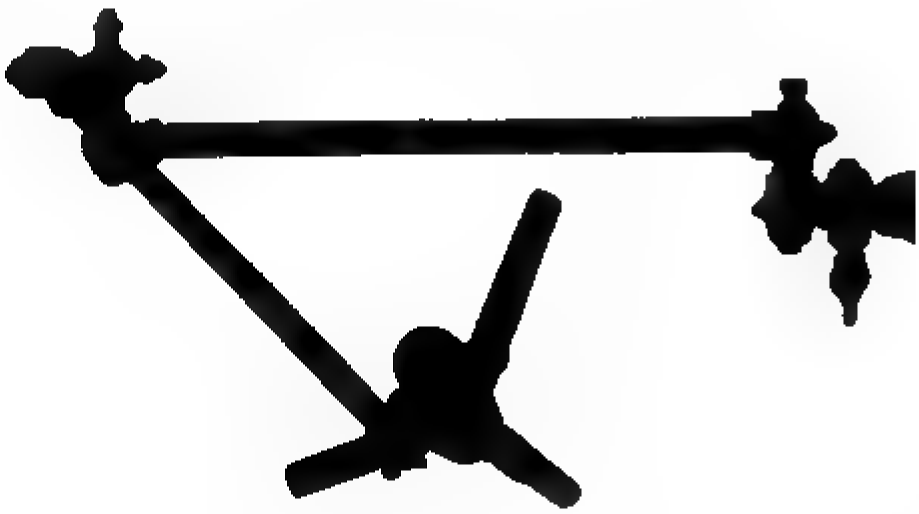

Fig. 123

jeweller's triple burner, one of which is a Bunsen. This burner is especially useful because it can be attached to a jointed bracket, thus doing away with the gas-saturated rubber tubing. One of the other burners gives a light flame, and the third burner gives a flame suitable for soldering. These extra burners are often convenient. The burner in the upright position only is in commission, and when any one of the burners is turned straight downward the gas is cut off from all of them.

Construction.—The Bunsen burner consists of a straight tube with a suitable-size hole near the lower end for the admission of air in sufficient quantity to produce instant combustion of the carbon, thus giving a blue, smokeless flame.

Nature of the Bunsen Flame.—Fig. 124 is an illustration of the Bunsen tube and flame. A flame is gaseous matter heated to a state of incandescence. The flame has a three-cone structure: *A* shows the mixed gas and air being heated; the inner edge of the light cone *B* indicates that the gaseous mixture has reached the state of incandescence and has become a flame; the outer edge of the light cone *B* indicates where the

Fig. 124

greatest heat has been attained and that the flame from this point outward is cooling until the outer edge of cone

FIG. 125

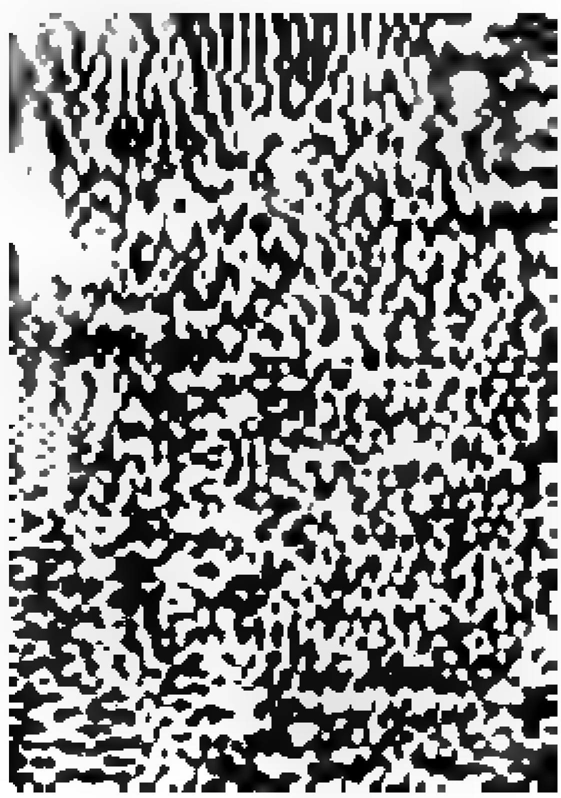

FIG. 126

FIG. 127

C is reached. At this point the mixed gases have become chemical compounds and cooled below the temperature of incandescence, hence the flame ceases to exist. It is evident

that the greatest body of heat is between *B* and *C*, consequently this is the portion of the flame in which to quickly heat an instrument.

Fig. 125 is a gas stove of many Bunsen jets, and is suitable when a much greater amount of heat is required than can be produced with the small burner.

Alcohol and Gasolene.—In some of the large office buildings in cities, and in many of the small towns, gas is not obtainable as a source of heat; then recourse must be had to either alcohol or gasolene. Alcohol is suitable as a substitute for

Fig. 128

the Bunsen burner for working wax and resinous compounds; it is cleanly, odor not offensive, but the heat is slow. Fig. 126 shows a good form of waxing lamp. Gasolene is more powerful and less expensive, but the odor of the material and of the product of its combustion are disagreeable. Fig. 127 is an excellent Bunsen burner. Fig. 128 is a large heater suitable for general heating purposes in the laboratory.

Petroleum.—Oil seems to be better adapted for the vulcanizor than either alcohol or gasolene. The lamp for using oil needs no description, for a suitable oil burner may be had for every make of vulcanizer.

TECHNIC OF CONSTRUCTION FOR COMPLETE VULCANITE DENTURES.

Synopsis.—Diagnosis and prognosis; impressions; casts; base-plates; occlusion and contour models; mounting on the New Century Antagonizor; grinding and setting up the teeth; trying in; flasking; packing; vulcanizing, and finishing.

Diagnosis and Prognosis.—The imaginary patient for whom complete artificial dentures are to be constructed is a lady, aged forty to fifty years, of the blonde type, but not stout built, the face oval modified by the triangle form, and good health. The mouth has been edentulous for at least two years; the gums are well resorbed and oval in form; the vault is medium in height and oval in form. There is a moderate amount of submucous tissue underlying the mucous membrane; no pronounced hard or soft places, and the fluids of the mouth abundant but not ropy. A normal average case. The prognosis is favorable, provided the personal equation does not present unusual difficulties.

Impressions.—For the upper impression, see Chapter II; classification, normal. Points to give attention: Tray with flanges low enough not to be displaced by any muscular action; palatal border wax accurately adjusted; cuspid eminence wax; plaster with hastener mixed thin; heel of tray adjusted first; lip raised while adjusting the anterior portion of tray; tray supported with the index finger in the center of the vault; lip and cheeks drawn downward marking the frenæ, and external compression.

For lower impression, see Chapter II; classification high ridge, broad. Points to give attention: Flanges; lingual wax roll; plaster with hastener mixed thin; the buccal tissues drawn from under the buccal flanges; frenæ marked; external compression, and the tray held in place by pressure of the thumbs in the bicuspid region.

Casts.—The impressions are permitted to stand for a few minutes, then varnished with thin shellac, and when dry (three to five minutes) with thin sandarac. As many coats of sandarac should be applied as may be necessary to secure a glossy surface, permitting each coat to dry before applying

the next one. The cast may be made of plaster of Paris, Prothero's Oxychloride of Magnesium, Weinstein's Artificial Stone or Spence's Plaster Compound. The writer has implied if not expressed his appreciation of the relative merits of these materials. However, for emphasis he will say that pure plaster of Paris is far the least suited, for casts upon which to vulcanize, of any of the materials used. Oxychloride of Magnesium has certain properties superior to any other known material, but the quality of the material obtainable is too unreliable at the present time, and will not be reliable until it is properly marketed. The artificial stone is undoubtedly placed upon the market as a substitute for Spence Compound. It is very much slower setting than Spence Compound and it is questionable whether it has any superior qualities. The Spence Compound has steadily grown in favor for the past sixteen years and the writer is convinced that he is not justified in discarding it for any other known material. However, tomorrow he may, for his mind and practice are always open to conviction and acceptance of the best, which he now believes to be Spence Plaster Compound.

The last three named materials form very hard casts which are difficult to carve into form, therefore it is desirable to have a technic that will produce the required form in the plastic state. This can best be done by wrapping or boxing the impression.

Wrapping Technic.—Cut a sheet of pink paraffin wax, lengthwise, into thirds. Warm and wrap these strips about the impression so as to enclose it and produce the form desired. The joints in the wax are lapped and luted with a hot spatula, also the wax is securely attached to the impression by application of the hot spatula. A portion at a time of this wax rim is warmed and pressed closely to the impression so as to give the desired outline margin of the impression for the cast. This can best be done by conforming the wax to the impression with the thumb of one hand and at the same time molding the free flange of wax with the thumb and finger of the other hand. After which a second layer may be added and luted at any weak part. Fig. 129 shows upper and lower encased impressions and Fig. 130

shows an encased impression filled with Spence plaster compound. Any of these materials should be well jarred into the

Fig. 129

impression by rapping upon a block of wood. The material should be jarred in until no more air bubbles can be brought to the surface. If the surface of the cast is not solid and free

Fig 130

of all air holes it is *positive evidence that it was not sufficiently jarred in* while filling.

Base-plates.—Heavy tinfoil (Nos. 20 to 60) is placed upon the cast, over which a sheet of paraffin base-plate wax is adjusted (any of the resinous base-plate stock material may be substituted for the paraffin). Soft wax is built upon the base-plates to form the occlusion and contour models as described in Chapter IV.

Occlusion and Contour Models.—The models formed on the casts are tried in the mouth, removed and added to or cut away as may be necessary to give the proper restoration of the lower third of the face at rest. The models should be tested with a spatula, to see that they rest with uniform pressure upon all portions of the alveolar processes. The patient is exercised in the forward and backward movements of the mandible. These movements being made at command, the mandible is placed in the retruded position and the occlusion guide lines, the high- and low-lip lines, and the median line recorded in the wax. The lower model is removed from the mouth and the bite gauges adjusted. The model is then replaced and the mouth closed in the protruded position, recording the inclination of the condyle path. The bite gauges are removed from the lower models and the fork of the face bow attached to the upper model. The face bow is adjusted and the relationship of the wax model to the condyle secured. (See Chapter IV.)

The student could justly conclude that all of the preceding work is done at one appointment with the patient. However, it is not necessary to detain the patient after the impressions are secured; a second appointment may be made for the next step. During the absence of the patient the impressions are glossed, filled, and permitted to harden for an hour or two. The impression is then removed from the cast (see Chapter III), the base-plate formed, and the preliminary work done upon the wax model. At the second appointment the wax models are adjusted to the mouth and the required data of marks and measures secured. The color of the teeth is selected. The detail of determining the color cannot be discussed; suffice to say that this phase of the science will be discussed in the chapters on Porcelain Teeth and Esthetics; also that the color for the type of the imagi-

nary patient must be straw yellow modified with gray, probably shade 39 or 41 of the S. S. W. shade bar; possibly as much toning with gray will be required as represented in shade 40 (shades 15, 16 or 20 trubyte teeth). The patient is again dismissed with an appointment for another sitting. During the absence of the patient the casts and wax models are mounted upon an antagonizor, the teeth selected, ground, and set up. At the third appointment the teeth mounted on wax are tried in the mouth. The details of this sitting are discussed in the chapter on Esthetics. At the fourth appointment the finished dentures are placed in the mouth and thoroughly inspected before dismissing the patient.

Mounting on Antagonizor.—The face bow with the wax models and casts are assembled and mounted on the New Century Antagonizor, as described in Chapter V. The face bow removed, the bite gauges are used to secure the inclination of the condyle path, also described in Chapter V.

Grinding and Setting Up.—A section of the wax of the upper model, represented by the median- and high-lip lines, is removed with a warmed wax knife (Fig. 102). The esthetics involved in selecting the artificial teeth cannot now be discussed: however, a rule may be given for determining the size of the teeth. *Length:* The length of the teeth selected should be sufficient to fill the space between the high-lip line and the occlusal plane. *Width:* The crest of the cuspid teeth beginning with its cusp should be continuous with the crest of the cuspid eminence developed in the contoured wax model (see Chapter I, also Fig. 2); therefore the combined width of the central, lateral, and the mesial plane of the cuspid is the length of the space from the median line to the crest of the cuspid eminence. The distal plane of the cuspid and the bicuspids and molars should fill the space between the crest of the cuspid eminence and the maxillary tuberosity. This rule for length and width is only applicable to normal or nearly normal cases. Extreme and abnormal cases cannot be classified, and artificial teeth must be selected according to the judgment of the prosthetist.

Grinding.—There are two stages of grinding a set of artificial teeth. The first stage is grinding for occlusion

at the time of setting up the teeth. The object is to gain as large a contact surface as may be expedient, and so to face the surfaces as to crush the food without dislodging the dentures. The second stage is at the time of final finishing of the dentures, and is designed to produce edges for catching and cutting the food; also to remove such points as may interfere with antagonization. The first stage of grinding may be done before any of the teeth are set up, or each tooth may be ground just before setting up. The first method is more expeditious for an experienced workman, but the second method is more comprehensible for the student and is the one here described.

Fig. 131

If the new forms of teeth of the best manufacturers are selected, little or no grinding of the bicuspids and molars will be needed. Each manufacturer has the new forms designated by trade names implying that they are anatomical.

Setting Up.—As the patient is in middle life, the anterior teeth must be ground to represent slight wear. This is done by slightly grinding the incisal edge of the incisors so as to give a moderately sharp, straight edge, removing the rounded edge of youth. The central incisor is set in place and secured with melted wax (Fig. 131). Setting up the teeth may be facilitated by placing a small roll of softened yellow wax upon the wax model into which the cervical end of the teeth

are pressed and thus held while the lingual portion is being filled with melted wax. This lingual wax may be added by dropping on from a pencil or stick of wax, the end of which is melted in the Bunsen flame, or the melted wax may be carried to place in a wax spoon (Fig. 102). The lateral incisor, with its incisal edge straightened, is set next to the central. The cuspid with its mesial incisal edge ground, thus placing the apex of the cusp more distally, is secured in place. These three teeth fill the space from the high-lip line to the occlusal plane, and from the median line to and including the cuspid eminence. Their labial surfaces describe the segment of an arc, the radius of which is the straight line from the mesio-incisal angle of the central incisor to the disto-incisal angle of the cuspid. The buccal surface of the bicuspids and molars form a straight line, but one which diverges from the median plane of the mouth. The bicuspids and molars are all ground so as to present three surfaces to its antagonist. This is best understood by studying Figs. 132

Fig. 132

Fig. 133

and 133. The bicuspids must have the three planes upon both the mesial and distal occlusal surfaces, while the molars have but the three straight planes. The first and second bicuspids and first molar (see Fig. 131) are set in order with their buccal surface forming the straight diverging line.

If the segment of the circle described by the three anterior teeth is continued, it will pass through the buccal cusp of the first bicuspid and diagonally through the sulcus of the second bicuspid (Fig. 10). The second upper molar is not set until the lower teeth are mounted. The wax about the six mounted teeth (Fig. 131) is smoothed and cooled so as to securely hold them.

The segment of wax between the median and high-lip lines upon the other side of the wax model is removed with a warmed wax knife. The six teeth for that side are then ground, set up, and waxed securely.

The method for grinding and setting up the lower teeth is similar to the upper; however, there are some important modifications. The section of wax defined by the median- and low-lip line upon either side is removed and a small roll of wax added into which the cervical end of the teeth are inserted. The grinding of the lower teeth differs from that of the upper in this: The facet formed on the incisal edge of the upper looks lingually, while that formed upon the lower incisors looks labially. The mesial edge of the upper cuspid is extended, while in the lower cuspid the mesial edge is shortened. The mesiodistal groove formed in the upper bicuspids and molars is on the buccal side of the center of the tooth, while it is placed lingually on the lower (Fig. 132).

There are two methods for setting up the lower teeth. One method begins by setting first the second bicuspid so that it shall accurately intercuspate with the upper first and second bicuspids. This is followed in order by the first bicuspid, cuspid, lateral, central, and then the first molar. The other method begins with the central incisor and continues in order backward. The reason for beginning with the anterior is to assure the desired expression, and that the lower teeth shall be clear of the upper ones by nearly one-sixteenth of an inch. The upper anterior teeth should overlap the lower, but for mechanical reasons they cannot overlap one-third the length of the crown, as in typical natural teeth. The amount of the overbite will be governed by the angle of the condyle path, and will be adjusted at a later stage of

the operation. The difficulty encountered by this method is to get the bicuspids to interlock. This often requires that the anterior teeth overlap each other laterally, especially the cuspid overlapping the lateral. To properly overlap any of the anterior teeth, either lower or upper, the mesiolingual angle of the overlapping tooth should be ground away for nearly its entire length. Also to interlock the bicuspids it may be necessary to soften the wax about the upper bicuspids and molar and move them backward. *However it may be accomplished, the bicuspids must interlock or intercuspate.* These six lower teeth being secured with wax,

Fig. 134

the segment of wax on the other side of the median line is removed and the six teeth mounted on that side. Fig. 134 shows the twelve upper and the twelve lower teeth mounted to a straight horizontal plane. Should any of the teeth be loose in their setting, they are made fast by remelting the wax about them with an ironing spatula (Fig. 101), and the wax about all of the teeth thoroughly chilled for the next step of setting the lower second molar.

A portion of the hardened wax just back of the lower first molar is removed and a ball of softened wax set in its place. The occlusal surface of the second molar is ground into the

same form as that of the first molar, and set upon the softened ball of wax. The plane of the occlusal surface of the second molar should be nearly parallel with the plane of the condyle path, and the tooth should be so placed that the disto-occlusal margin of the upper first molar will glide upon the buccosulcus plane of the lower second molar when the teeth are placed in lateral occlusion. Fig. 135 shows the teeth in lateral occlusion and the disto-occlusal margin of the upper first molar in contact with the lower second molar. It is obvious that if all the teeth but the lower second molar are set in hardened wax, and it in softened wax, working

Fig. 135

the condyle joint forward and backward repeatedly will aid in properly adjusting the second molar. Correctly placing the three molars, the upper first and the lower first and second, is the key to the mechanico-anatomical antagonization; and the secret for success in the adjustment of these molars is in keeping the disto-occlusal margins of the first molars *down*. They may be depressed a trifle below the plane, but never elevated above the plane. Herein is the distinction between the mechanico-anatomical arrangement of artificial teeth and the variously advocated "anatomical" arrangement of them. By observing Figs. 1, 2, 3, and 4 it will be seen that the anatomical arrangement of natural

upper teeth is that the occlusal surfaces of all the teeth, from the central incisors to and including the distobuccal cusp of the first molars, are in a straight horizontal plane, and that the second and third molars are not tilted, but stepped, upward. So far as the author knows, no advocate of the so-called "anatomical articulation" has ever suggested reproducing this upward stepping of the second and third molars. Hence there never has been a system of anatomical arrangement for artificial teeth, for they have all been adaptations, and all to a greater or less extent have opposed a physical law. The physical law is that "force moves at right angles to the surface from which it emanates." Therefore it is evident that the system that least opposes this physical law is superior in at least this one respect. It is evident that if the molars are tilted upward at any angle (the greater the angle the greater the leverage), the closing movement of the mandible must force the upper denture forward, and that if it were not for the interlocking of the bicuspids the denture could not be retained in its place. As the first molars must assume the burden of crushing hard food, it is logical to reason that their occlusal surfaces should be parallel to their alveolar base of support. If the crushing of food were the only function of artificial dentures, then the second molars should be placed in the straight occlusal plane; however, it is important to grind the food, and to have the dentures so constructed that they are balanced in any position in which they may be occluded. To obtain this balanced relationship of artificial dentures it is necessary to have more or less of the teeth placed in harmony with the condyle path; but to secure the greatest effectiveness in crushing and grinding the food, it is necessary to have as few teeth out of the horizontal occlusal plane as possible, hence the short-balancing curve, or "compensating curve." This term, "short-balancing or compensating curve," is in contradistinction to the *long* "compensating curve," as first taught by Dr. Bonwill.

Having developed the philosophy of this peculiar arrangement of these three molars, a return may be made to the technic.

In like manner the three molars are adjusted on the other side of the case.

Many of the new forms of molars have long lingual cusps on the upper and deep sulci on the lower ones. By this means a nearly straight occlusal plane is secured which favors retention.

Fig. 136

Proving the Antagonization.—A critical study should now be made of the antagonization of the teeth as mounted. For this purpose the antagonizor is grasped so that the thumbs and fingers may manipulate the condyle paths, and the three movements (incisal, right and left lateral) are repeatedly produced. This will disclose any imperfections in the alignment of the teeth. Should any of the teeth prove to be too long and interfere in the varied movements, they may be intruded or ground upon the lathe. The teeth may be ground while mounted in wax, provided light pressure

is used in holding them against the stone, and the stone is *sharp* and *true running*. The requirements of well-antagonized teeth are that there shall be sufficient points of contact in any position in which they may be closed, in ordinary use, to balance them, or to prevent their displacement. If the teeth are placed in incisal occlusion, as shown in Fig. 136, the upper and lower incisors will be in contact, also the upper first molars (disto-occlusal margin) will be in contact with the lower second molars. It will be only incidental and owing to an irregularity of alignment should

FIG. 137

there be any points of contact between the incisors and molars, for the upper teeth describe a straight line and the lower, by inclining the second molar, describe a concave line; and a concave line can be in contact with a straight line only at its extremities. The teeth being in right lateral occlusion, that is, the lower carried to the right (Fig. 137). there will be many points of contact on the right side but no contact on the left side, except, because of the pivotal movement, the lower second molar is carried forward and is in contact with the disto-occlusal margin of the upper first molar. This gives the so-called three-point contact, as

represented by the molars upon the left and the cuspids and molars on the right side. The teeth being placed in the left lateral occlusion (Fig. 138), the same relations are established for that side.

In this critical study of the antagonization of the teeth it should be apparent that there is a relationship between the lateral inclination of the bicuspids and molars and the angle of the condyle path. The difference in width of the maxilla and the mandible, in the bicuspid and molar region, necessitates that these teeth are more or less laterally

Fig. 138

inclined; and that the plane described by the lateral movement varies from straight to sharply concave, with the concavity upward. If the condyle path is horizontal, the lateral movement plane will be straight; but if the condyle path is nearly perpendicular, the lateral movement plane will be sharply concave. This is demonstrated by two blocks of plaster mounted in the antagonizor, and the lateral movements made until the blocks are so ground that they will be uniformly in contact at every point, while in the lateral movement. If the teeth have not been correctly inclined while mounting, they may be corrected by softening the wax

about the cervical ends of the teeth with a hot ironing wax spatula and moving the cervical ends either inward or outward as required. It may be necessary to remove certain of the teeth and deepen the sulci and possibly shorten some of the cusps. When the teeth are ground and mounted so that they may be moved in any direction (three), and, not meet with interfering points, also have the largest amount of contact surface, the critical study and correction may be considered as completed. Time used in this critical work is well spent.

To complete the mounting of the teeth sufficient wax is cut away to permit the upper second molars being set in occlusion with the lower second molars, which are fixed in position with melted wax.

It is noticeable in some of the illustrations that there is a space between the lower first and second molars. The reason for this is that by carrying the second molar forward, surface contact cannot be gained, only a V-shaped space formed, while by carrying it backward it affords a longer gliding surface for the upper first molar and a larger contact surface for the upper second molar.

OTHER METHODS FOR ANATOMICAL ANTAGONIZATION.

What is meant by anatomical occlusion or antagonization? It means that the artificial teeth are mounted in a manner compatible with the laws of nature, but not necessarily, and rarely are they reproductions of nature, for nature rarely attains perfection in our conception of her ideals. However, nature's laws are immutable and not violable with impunity; therefore the prosthetist must, if he desires the best results, bring his artificial creation into compatibility with nature.

There are three laws of nature that an artificial denture shall not, with impunity, violate:

1. The law of resistance of a tissue to compression.
2. The law of freedom of movement of a tissue.
3. The law of direction of force.

As an artificial denture must compress the soft tissue upon which it rests, it follows, as a logical sequence, that the larger the surface and better distributed the pressure the less resistance, and, consequently, nature will better tolerate the artificial appliance. However, an artificial denture riding upon a muscle is retarding the free movement of that organ, and if the contracting power of the muscle is greater than the retaining power it must dislodge the denture; therefore there is in each individual case a circumscribed surface upon which the artificial denture may rest securely, but beyond which it is insecure and a source of irritation. The base-plate outline and adaptation being secured, the third factor, the law regulating force, must be complied with. This consists of mounting the teeth in such a manner as best to meet opposing forces—antagonism—antagonization. Therefore anatomical occlusion (closed teeth—passive), a better term is anatomical antagonization (opposition—active), reduced to its lowest denomination, may be defined as a factor in retention of artificial teeth. Important as is this factor, it is only one of several factors equally important. It is founded upon anatomical knowledge, therefore scientific; but it is pure mechanics. This scientific mechanical operation is a superstructure resting upon a substructure (base-plate), and it is dependent upon the secure or insecure foundation—impression. Therefore a properly taken impression is the foundation, the key to success. The substructure (base-plate) is next in importance, and if made from a tested impression is quite simple; but as few impressions taken are tested and perfection assured, the base-plate constitutes a very uncertain factor as a support for the superstructure—anatomical occlusion.

To more fully appreciate the relative importance of anatomical occlusion in the scheme of restoring lost dental organs, it is well to classify the essential factors entering into such restoration.

Thus it is seen that anatomical occlusion is a control by the physical laws of leverage. As leverage is the most powerful force utilized by the prosthetist it becomes of great importance. Anatomical occlusion probably has had, and

is having, more profound study than any other phase of prosthetic dentistry, as evidenced by the inventive genius displayed since 1840, the date of the first so-called anatomical articulator. Nevertheless, one must not lose sight of that other great factor, esthetics, for a part can never equal the whole, and the perfect artificial denture is the thing desired.

Classification:

- Factors
  - Anatomy
    - A thorough knowledge of the various hard and soft tissues of the mouth—their form, action, and controllability.
  - Retention
    - Measurements consist of
      - Impressions and casts.
      - Occlusion and contour models.
      - Movements of the mandible.
    - Physics includes
      - Molecular attraction.
      - Atmospheric pressure.
      - Leverage, *i. e.*, anatomical occlusion.
  - Esthetics
    - Color.
    - Forms.
    - Contours.

What constitutes the distinction between plain occlusion of the teeth and the designated anatomical occlusion? Plain occlusion consists of arranging the teeth in the normal relationship of their morsal surfaces. Anatomical occlusion is an addition to plain occlusion, and consists of placing the teeth in such a position as to create the so-called "three-point contact." Plain occlusion is nature's perfection, and should always be striven for in every mounting of artificial teeth. The three-point contact is rarely found in natural dentures and is entirely unnecessary. However, three-point contact is essential and is perfection in antagonization of artificial teeth. Three-point contact is a name applied to the operation of arranging artificial teeth so that they balance in incisal and lateral occlusion as well as in normal (retruded) occlusion. It is the control of the laws of leverage, therefore essential to perfection in artificial dentures. As before expressed, anatomical occlusion is a factor only in retention of artificial dentures. Anatomical occlusion, viewed in the naked form, seems a very simple thing, but it is not; the subject has been coexistent with dentistry

as a profession, and is still a profound subject for investigation. It is believed that all the movements of the mandible are now understood, also instruments invented to produce them; but no one knows what the future may have in store for us. It is certainly true that the profession is being flooded with inventions designed to make perfect this operation. Judgment is always an essential factor even with the most highly developed instrument on the market.

These questions arise in our mind: (1) Are these expensive and elaborate instruments necessary? (2) Can perfect results be produced with them? (3) Are all the instruments called anatomical equally good, and, if not, which is the best? If an answer in a word were required to all these questions it would have to be, No. However, that would be a very unjust way of disposing of the subject, for it is probably true that the vast majority of the profession is not qualified to make use of the knowledge or the best instruments now obtainable. Probably the Snow, Gysi and Hall instruments are the most scientific and practical instruments yet placed upon the market. However, the Hall is of a class diametrical to the other two in this, the Hall is constructed upon the principle that the teeth and muscles direct the movements of the condyle, whereas the other two are constructed upon the principle that the condyle and muscles control the movements of mastication. Therefore the Snow, Gysi and Hall instruments and methods only are considered *in extenso.*

Anatomy.—A thorough knowledge of the structure and use of the hard and soft tissues composing the masticating apparatus is necessary to fully comprehend anatomical occlusion; however, a résumé only can be given here, and Gray's *Anatomy* should be consulted. Four bones enter into the upper jaw, the two maxillary and palatal, while the lower jaw has but one, the mandible. The upper jaw is the fixed or stationary base, while the mandible is a lever or swinging arm attached to the cranium by ligaments and muscles. The attached end of the mandible (either end) is called the condyle, the portion of the temporal bone into which it sets is called the mandibular fossa, and the anterior inclined curved surface of this fossa is spoken of as the

articular tubercle. The condyle is separated from the fossa by a cushion of membranes and ligamentous tissue, and the two (condyle and fossa) are united, in part, by a capsular ligament attached below the head of the condyle and at the periphery of the mandibular fossa. This forms a peculiar ball-and-socket joint. There is no fixed rotating center. In a simple open-and-shut movement Dr. Snow has said: "At first the circular surface of the condyle moves as from a pivot in the synovial sac, the center of the movement being at the center of its curved surface. When the backward swing of the ramus has taken up the slack in the external lateral ligament (sphenomandibular) the lower edge of that ligament determines the center about which further movement is made." The condyle instead of being spherical is an elongated flattened spheroid. Its long axis is approximately at right angles to the ramus of the mandible; but is doubly oblique, that is, it is slightly inward, downward, and backward with so many variations that it is difficult to recognize the rule. Hence the movements of mastication may be considered as a component of the various movements of the mandible. To construct an instrument admitting the reproduction of all the rotation points formed in the gyrations of the mandible seems now to be complicated and impracticable, and probably entirely unnecessary. The Kerr antagonizor was an attempt at producing the anatomical rotation joint, while the Gysi Adaptable establishes an average rotation point variable in one direction only.

This third movement of the mandible (lateral) was recently described by Mr. Norman G. Bennett, of England, and measured by Professor Gysi, of Switzerland.

These three movements of the mandible—open and shut, forward incisal, and lateral mandibular—are the important factors in anatomical occlusion. The Gysi adaptable antagonizor, with the three measuring instruments, is a valuable aid in comprehending and demonstrating these movements and their importance. It is probably the only instrument upon which it is possible to approximately reproduce all three of these movements of the mandible. Even with this instrument the teeth mounted in wax should be

tried in the mouth for final adjustment. There is a reason for this: All three measurements are made by use of an insecure base-plate resting upon the mandible, consequently are not absolutely dependable. It is true that an expert, painstaking scientist, and operator like Professor Gysi will produce quite accurate results with these instruments; but it is hardly reasonable to expect satisfactory results by even the average operator, to say nothing of those inexperienced in handling instruments of precision and below average ability. A well-developed anatomical antagonizor is desirable for the laboratory, but the perfection, the human anatomical antagonizor, is necessary for the operating-room.

It is thought by some that the pivotal center of the open-and-shut movement should be reproduced in the antagonizor, and by other authorities that it is of no practical value in mounting artificial dentures. The writer is of the latter opinion, because this pivotal center exists only as the mandible is being moved from the maxilla, and returned to contact, when the pivotal center is instantly transferred to the surface of the condyle and remains there during the triturating movements of mastication. The writer is further of the opinion that the lateral incisal movement is of negative importance; but that the lateral mandibular and the forward incisal movements are important; also that the essential portion of these operate from the top of the condyle. If this belief and reasoning are true to nature, then the variable lateral rotation center of the Gysi adaptable antagonizor is unnecessary; but the lateral and vertical movements of the condyle are scientific and necessary for the greatest accuracy; however, as these measurements are obtained by an insecure attachment to the mandible, the accuracy of the measurements are very questionable. In the Snow Twentieth Century Antagonizor the vertical movement or forward incisal only is reproduced; but the Snow new "Acme" has the forward incisal and lateral mandibular movements; as has also the Hall. However, these two movements, forward incisal and lateral mandibular are quite different in development in each of the three instruments, Adaptable, Acme, and Hall.

There is still the question of the importance of an exact measurement of the base line of the mandibular triangle. Dr. W. C. Dalbey, of Du Quoin, Illinois, in an interesting paper in the March, 1914, *Dental Cosmos*, lays much stress upon the importance of the length of the base line of the triangle. He has invented an instrument for its measurement. If the gyrations of the mandible were from a fixed rotating center as in a mechanical antagonizor, then undoubtedly the length of the base line of the triangle would be an important factor; but as it is a remarkably adaptable joint and one of its most important movements is lateral, its exact measurement may be unimportant. It is important, however, to have all points of the occlusal plane in harmonious relation to the base line of the triangle. This is the sole function of the face bow. It must be evident to a reflective mind that this lateral mandibular movement emphasizes the three fundamental horizontal longitudinal planes of the bicuspids and molars as illustrated in Figs. 132 and 133, therefore in grinding away interfering cusps they should be reduced in the direction to these longitudinal planes. However, this does not imply removing the cusps to a flat surface, but enough only to relieve the interference.

Recently, while in Washington, D. C., the writer, through the kindness of Curator Hrdlicka, of the Smithsonian Institution, had the privilege of examining and measuring a series of mandibles of that great collection. Limited time only prevented a more extensive study.

The following tabulation, while not extensive enough to establish the fact, is elaborate enough to be suggestive, and to aid in a developing conviction; that is, that the mandibular equilateral triangle is the exception and not the rule:

Mandibular triangles.	Mixed whites.	German whites.	Egyptian.	Eskimo.	Patagonian Indian.	Mixed Indian.	Mongolian.	Australian Islanders.	Totals.
Equilateral	8	2	3	1	5	..	..	..	19 (6%)
Isosceles	35	18	47	20	47	12	3	5	187 (64%)
Scalene	17	10	17	13	20	7	2	..	86 (30%)
Totals	60	30	67	34	72	19	5	5	292

The average triangle of the 60 mixed whites had a base of 9.8 cm., and the right and left sides 10.4 cm. each.[1]

The average triangle of the 30 German whites had a base of 9.7 cm., the right side 10.46 cm., and the left side 10.5 cm.

The largest side of the triangle in the 90 whites was 11.4 cm. for both the right and left sides, of which there were 3 of each, and 1 base reached a magnitude of 11.2 cm.

In the mandible of the 90 whites there were 2 base lines longer than one lateral side and 2 base lines longer than either lateral side. In the remaining 202 measurements there were 5 instances in which the base line was longer than a lateral side and 6 others in which the base line was longer than either lateral side.

While balance, the so-called "three-point contact" is the essential and fundamental factor of anatomical occlusion, it is dependent upon several other operative procedures. These associated factors can here be named only, as each factor is a chapter by itself. They are: impressions, casts, base-plates, occlusion and contour models, and measurements. Anatomical occlusion emphasizes the importance of each of these factors, especially the base-plate and occlusion model. A base-plate of wax is very unsatisfactory for this work. A well-adapted resinoid base-plate is much better, but perfection requires a base-plate of *vulcanite* or *metal*. Having suitably formed base-plates and occlusion models, and the measurements obtained, the casts and occlusion models are mounted upon the antagonizor.

Occlusion of the Teeth.—Normal occlusion consists of the labial and buccal surfaces of the upper teeth slightly overlapping the same surfaces of the lower teeth. The morsal surfaces of the bicuspids and molars interlock one against two, except the upper third molar, and the six anterior upper teeth overlap the lower teeth (approximately) one-third of their length; but are not necessarily quite in contact with the lower ones. In normal occlusion the lower teeth, except the central incisors, are in advance of their

[1] 10.16 cm. equal 4 inches.

corresponding upper teeth. Plain occlusion of artificial teeth lays no stress upon the long axis of the teeth, but the long axis is the controlling factor in anatomical occlusion, the factor that controls the direction of force upon the artificial dentures in the various gyrations of the mandible. The two physical laws of force controlling leverage in antagonization of the teeth are: (1) Force moves in a straight line, and at right angles to the surface of its origin, and (2) the combined direction of two or more forces is their resultant. Therefore stability of a denture requires that the long axis of the teeth shall be at right angles to the plane of the jaws upon their buccal surfaces, but an oblique angle upon their distal surfaces; also that the resultant of the incline planes of the morsal surfaces of the molars and bicuspids must be at right angles to the base plane, but oblique in the plane described by a cross-section of the denture. It is apparent that when an artificial denture has one cusp only in occlusion with the opposing dentures it is impossible to have the long axis of the tooth as a resultant of all the lines of force that may bear upon it. Hence an auxiliary support may be had by so mounting the teeth that necessarily there is a second point of contact upon the opposite side of the denture, and still better if there can be three equidistant points of contact. This 's the basis of the so-called "three-point contact," and is exemplified in incisal occlusion and also in lateral mandibular occlusion.

Arranging the Teeth.—The six upper anterior teeth are mounted to the Bonwill dental circle *with such variations as may be required for esthetics.* The mounting of the bicuspids and molars should be considered as mechanical problems, and esthetics ignored just to the extent that the esthetic defects are not too glaring. The upper bicuspids and first molars upon either side are arranged in a diverging straight line. Their long axes diverge slightly outward so as to have full-face occlusion with the lower opposing teeth which converge inward. This will provide for the lateral mandibular three-point contact, provided the occlusal surfaces are properly formed and the long axes are correctly aligned; but it will not produce the incisal three-point

contact, which must be secured by setting the lower second molar and the overlap of the central incisor in harmony with the inclination of the articular tubercle. It is seen that the normal upper incisors overlap the lower incisors one-third of their length; this permits the lower second molars, when moved forward, to occlude with the upper first molars provided the condyle path is horizontal. If the condyle path is very oblique and there is a typical one-third incisal overbite (as seen in natural normal occlusion) the lower second molar (either side) would have to be set at an impracticable inclination, whereas by placing the overbite at the minimum the inclination of the second molar may be reduced.

There are two methods by which the three-point contacts may be produced. The one method has just been described and consists of placing the lower second molar in harmonious relation with the articular tubercle, the upper first molar and the central incisor. This method is necessary when using the older forms of artificial teeth. The second method consists of having molars with long lingual cusps, which is characteristic of the best of the newer forms of molars. The long lingual cusps of the upper molars, the deep sulci of the lower molars, and the slight or no overlap of the incisors compensate for the oblique condyle path and makes unnecessary the anterior obliquing of the long axis of the second molar; thereby adding to the effectiveness of the masticating surface of the second molars. In fact, if the lower second molar is placed in a very antero-oblique position, the stability of the dentures is enhanced by leaving off the upper second molar.

Professor Gysi instructs to set the upper bicuspids and molars directly over the crest of the alveolar ridge, with the lingual cusp of the first bicuspid slightly above the horizontal plane of the buccal cusp; the two cusps of the second bicuspid are in their same horizontal plane, while the lingual cusps of the molars are increasingly below the horizontal plane of their buccal cusps. He instructs to set the molars so as to slightly open the bite and then force into occlusion by placing the teeth repeatedly in right and

left lateral mandibular occlusion. This is a very simple and most effective technic for securing the lateral mandibular three-point contact. This is normal occlusion, or normal bite.

Cross-bites.—When there is an extensive disparity between the width of the upper and lower alveolar processes, better results may often be obtained by the cross-bite method. This consists of exchanging places with the molars and second bicuspids crisscross, that is, the upper right teeth exchange places with the left lower and the upper left with the right lower. This interchange of position necessitates some grinding. In time the cross-bite teeth of Professor Gysi's patterns will probably be upon the market. This cross-bite method of mounting places the buccal surface of the lower molars buccally to the buccal surface of the upper molars, thereby placing the teeth in better relation to the alveolar ridges and less interference with the movements of the tongue. However, in excessively resorbed ridges, this cross-bite is rarely required because the base plane is at the periphery of the base-plate rather than at the crest of the alveolus, and the normal bite is preferable. The cross-bite is especially indicated with prominent alveolar ridges, and contracted maxillæ, usually accompanied with a high vault.

Trial of the Teeth on the Human Anatomical Antagonizor.—If well-adapted base-plates, occlusion models, and measurements are obtained and reasonable care given to mounting the teeth anatomically, the wax being thoroughly chilled, the dentures are ready for proving in the mouth. Patients should be instructed that the teeth are mounted in wax and that they must not use force upon them unless they are instructed to do so. The teeth are placed in the mouth in normal occlusion and studied esthetically, then they are placed in incisal occlusion, and, with a thin-blade spatula, tested to see that there is equal pressure at the three points of contact. They are then placed consecutively in right and left lateral occlusion and tested in like manner. Should any of the teeth prove to be too prominent the wax about the elongated teeth is slightly warmed, replaced in the

mouth, and the teeth closed in the necessary occlusions to adjust them. Should any of the teeth be too short the wax is dried, the teeth raised and waxed, then adjusted to the mouth.

The anatomically occluded teeth may now be considered perfect and ready for mounting on vulcanite.

THE NEW SCHOOL.

The preceding pages on "Other Methods for Anatomical Antagonization" have developed since the first edition of this book was written, and at the preparation of this—the fourth edition—the author believes he is justified in announcing his conviction, that is, *that a new school of dental prosthetics is rapidly forming*. However, it would be very unwise for the colleges, the text-books, or the profession to judge hastily of the merits or demerits of either school of thought and technic; but they should earnestly weigh the evidence and thus form a mature conviction. Pope's advice is certainly timely:

> "Be not the first by whom the new are tried;
> Nor yet the last to lay the old aside."

The progress of dental prosthetics can be divided into three periods: (1) Empirical; (2) Bonwill School; and (3) New School.

The Empiric period was a necessary antecedent of the schools, and included the time up until thought upon this subject was crystallized into expression by Dr. W. G. A. Bonwill in 1864. His notable paper read before the American Dental Association well marks the beginning of a scientific school of thought and technic. All subsequent research and teaching have been based upon the work of Dr. Bonwill, hence it is only a just recognition that the followers of Dr. Bonwill shall be known as the Bonwill School. The Bonwill School was based upon five fundamental principles, namely: (1) mandible, a lever of the third class; (2) equilateral triangle; (3) fixed rotation centers; (4) dental circle; (5) alignment of the teeth. The Bonwill School probably reached its

highest development under Prof. A. Gysi, of Switzerland. Prof. Gysi did more than perfect the Bonwill School; he demonstrated and established the fact that the rotation centers were not on the head of the condyle, but anywhere in a sphere one inch in diameter, located back of the base line and about the sagittal plane.

About the same time Mr. Norman G. Bennett of England demonstrated the lateral mandibular movement from a vertical rotation center.

Prof. F. W. Frahm, then of the University of Denver, but now of the University of Southern California, demonstrated that one side of the face is not an exact counterpart of the other; therefore, that the Bonwill triangle is rarely equilateral. He also demonstrated the importance of the sagittal plane.

Dr. Rupert E. Hall, of Houston, Texas, but now of Chicago, demonstrated that it was not the temporomandibular joint in connection with the muscles; but the teeth and muscles that are the dominating factors in mastication, that the joint functions only as a compensating or a toggle joint. He also conceived the self-evident fact that it is the closing movement of the mouth that is of importance in mastication, and that, not until at least two points of opposing teeth meet. Dr. Hall has been most practical because he has taken all of these fundamental principles and created a most convenient instrument to aid in properly constructing artificial dentures.

That the author may not be misunderstood he quotes the *Standard Dictionary* definition of a profession: "An occupation that properly involves a liberal education or its equivalent, and mental rather than manual labor." He defines the operation of constructing artificial dentures as mental rather than instrumental, and would impress the fact that the knowledge of what is required is the first essential, and that an instrument is only a valuable aid. However, the desired results in denture construction may be produced upon any of the three modern instruments, but more simply and expeditiously upon the Hall. The author requests the reader to return to the first chapter of this book and study it carefully for therein is the justification for the new school. Following is Dr. Hall's description of his instrument and methods.

The Hall Method of Antagonization.[1]—*Theory.*—The Hall theory of the mandibular movements and antagonization is based on an extension of Bonwill's discovery that the ground plan of the human masticatory apparatus is the equilateral triangle.

Its development has demonstrated that the condyles are not the guide to the movements of mastication, but are merely the fulcra upon which the mandible moves; that the planes and the positions of the teeth are the guides of the mandibular movements, just as the rails guide the railway train. The movements of the mandible are complex, made up of a number of simple movements automatically operating simultaneously in concert as guided by the teeth. Only movements occurring when planes of two or more teeth are in contact are masticatory movements and are of importance to the prosthetist. In line with this idea, and recognizing the coördinate relation between the movements of the mandible and the planes of the teeth, the Hall theory adapts the mandibular movements to the planes and positions of the teeth, and not the planes and positions of the teeth to the condyle paths. It is obvious, therefore, that the reestablishment of correct masticatory movements must be effected, if at all, by means of artificial dentures that restore the proper relations of the planes of the teeth. Practical tests based upon this idea prove its correctness.

Let us first analyze these simple movements and then study them in combination.

1. We have the opening and closing movement, first in point of order because it is this movement that occludes the teeth and in turn is required to unlock them before other movements are possible. The axis of this movement runs in a horizontal plane at right angles to the antero-posterior aspect of the movable member—the mandible—and is located in a vertical plane below the heads of the condyles.

[1] The following description of the Hall instrument and method has been furnished for this book by Dr. Rupert E. Hall, of Chicago, Ill. The author has been intimately acquainted with the work of Dr. Hall for more than five years and unhesitatingly endorses the instrument and method as in his opinion destined to revolutionize the mounting of artificial dentures. They are remarkably simple, positive, and efficient.

2. We have the incisive movement, a movement in combination with the opening and closing movement, second in point of order because incision precedes mastication. The location of the axis of this movement is below and parallel with that of the opening and closing movement.

3. We have the mandibular lateral movement, a movement in combination with the opening and closing and incisive movements, third and last in point of order because its use is in movements of mastication which succeed those of incision. The axis of this movement lies in the median plane posterior to the condyles and in a plane oblique to the plane of the teeth.

Dr. Bonwill took the mandible as the basis for measurements. While it is true that the mandible is attached to the cranium, of which the maxilla is an integral part, it is also true that in nature's processes the mandible is first developed, the maxilla being thrown off as a lateral from it. But in making calculations for artificial reproduction of the movements of the mandible, we are compelled to work from a fixed basis. Quite evidently the mandible, which is freely movable in any direction, cannot form this basis. So we take the maxilla as the foundation about which to make our deductions.

Dr. Bonwill says the measurements of the upper jaw, though slightly larger, must conform to those of the lower. Conversely, then, the measurements of the mandible must conform to those of the maxilla.

The triangle of the maxilla is described by lines connecting the crests of the glenoid fossæ of the temporal bone with each other and with the contact point between the upper central incisors. The line between the crests of the fossæ is the base, the contact point of the incisors the vertex of the triangle. Theoretically, it is equilateral, with an average measurement of approximately four inches on each side. The triangle of the mandible is of the same form but slightly smaller, being described by lines connecting the centers of the crests of the condyles and the contact point of the lower central incisors.

The altitudinal lines of both triangles are in the median plane or the sagittal plane of the skull. If the maxillary

triangle be conceived as folded back on its base as a hinge, its vertex will take the position in the region of the external occipital protuberance. The protuberance is thus seen to be at the same distance approximately from the condyles as the contact point of the upper central incisors and to form the vertex of a counter triangle to the maxillary triangle which we may designate the occipital triangle.

The triangle in these two positions will be in different planes and will form a dihedral angle corresponding approximately to the dihedral angle between two regular triangular pyramids placed base to base to form a double tetrahedron. A straight line between the two vertices—protuberance and contact point—will describe the so-called occlusal plane.

A complete geometrical demonstration would perhaps be too technical here, so only a brief résumé is presented.

The accompanying scheme (Fig. 139) shows the double regular pyramid founded on the mandibular triangle applied to the human skull in the development of the Bonwill idea to its legitimate conclusion. The maxillary triangle is superimposed, showing its relations with the mandibular.

A B C D represents the double triangular pyramid. *B* stands for the base of the mandibular or Bonwill triangle, the line connecting the crests of the condyles. *C* is the vertex of the mandibular triangle, the contact point of the lower central incisors. *A* is the external occipital protuberance, the position assumed by the vertex when folded back on its base. *D* is a basal corner of the double pyramid. Line *DB*, is the altitude of the figure in the vertical plane and intersects line *AC*, the occlusal plane, at right angles at *E*.

This demonstration points to point *A*—the external occipital protuberance—as the center of the mandibular lateral movement, to point *E* as the center of the opening and closing movement, to point *D* as the center of the incisive movement.

Taking the external occipital protuberance as the center of the mandibular movements, we have the lateral movement in the arc of a circle in the horizontal plane; second, the deflection of this movement vertically by its guide, the cusp planes of the teeth, the typical guiding inclinations of which

are 45 degrees. The determining guiding inclination of the cusp, that of the upper first bicuspid, is projected line *I J*. A line projected from the occipital protuberance intersecting the prolongation of the line *I J* at right angles determines the axis of the resultant compound movement so produced, line *K L*.

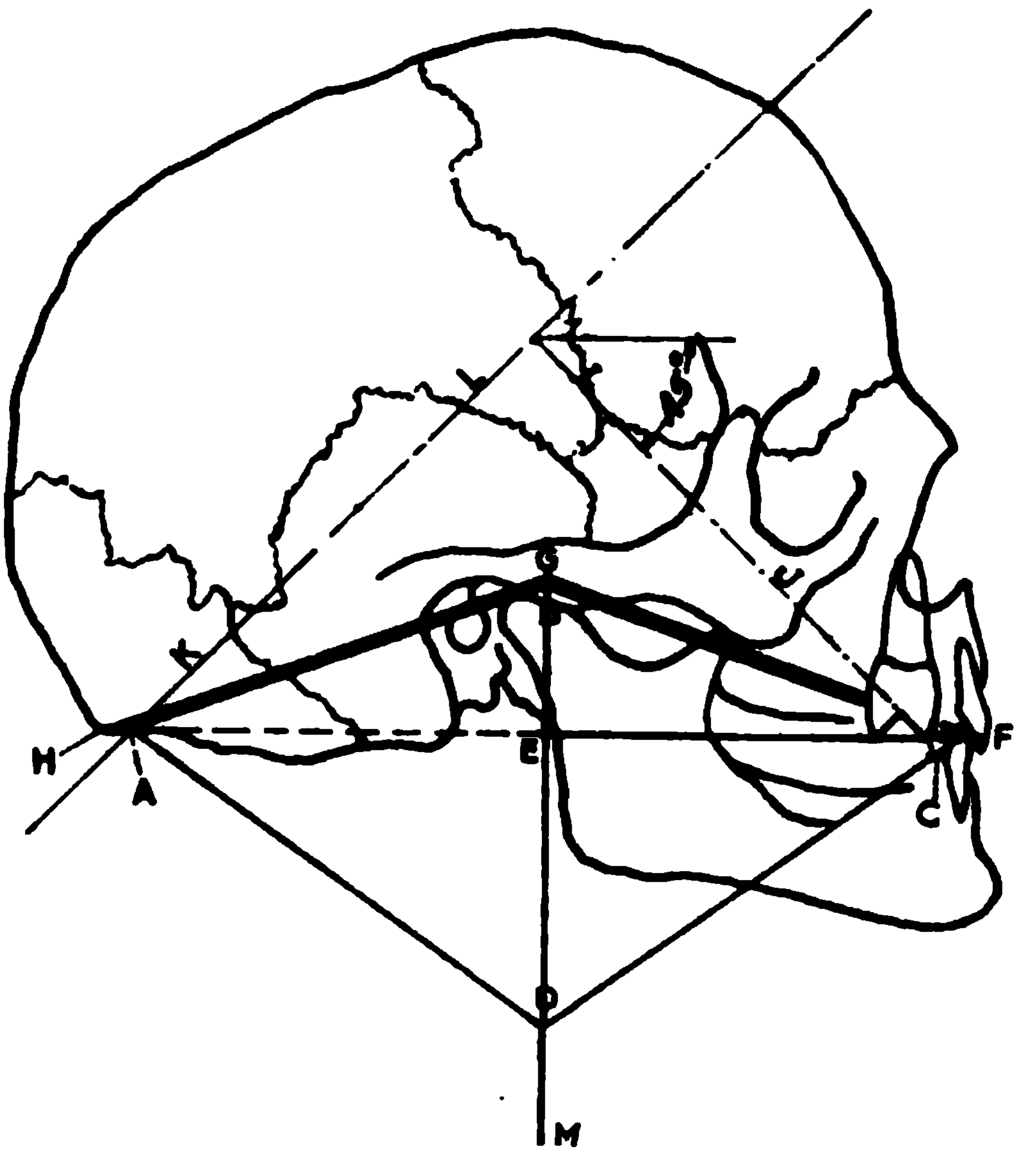

FIG. 139

The center of the incisive movement, while typically, located at point *D*, automatically finds its center in the line *E M* as guided by the overbite. The length of the line *E M* may be infinite.

The soundness of these theoretical conclusions as a basis for practice has been amply verified. Every practical case in which they are tested—without a single exception—adds to the cumulative affirmative evidence of their correctness.

The Hall antagonizor affords the means for reproducing all these movements and their combinations, including the automatic shifting centers of rotation, and provides perfect

antagonization and apposition of the planes of the teeth, giving the wearer the full advantage of the mandibular movements in the mastication of food. In centers of movements being adaptable, teeth of any cusp angle, any degree and inclination of overbite and arrangement may be mounted upon it with the certainty that they will work in the mouth precisely the same as in the articulator.

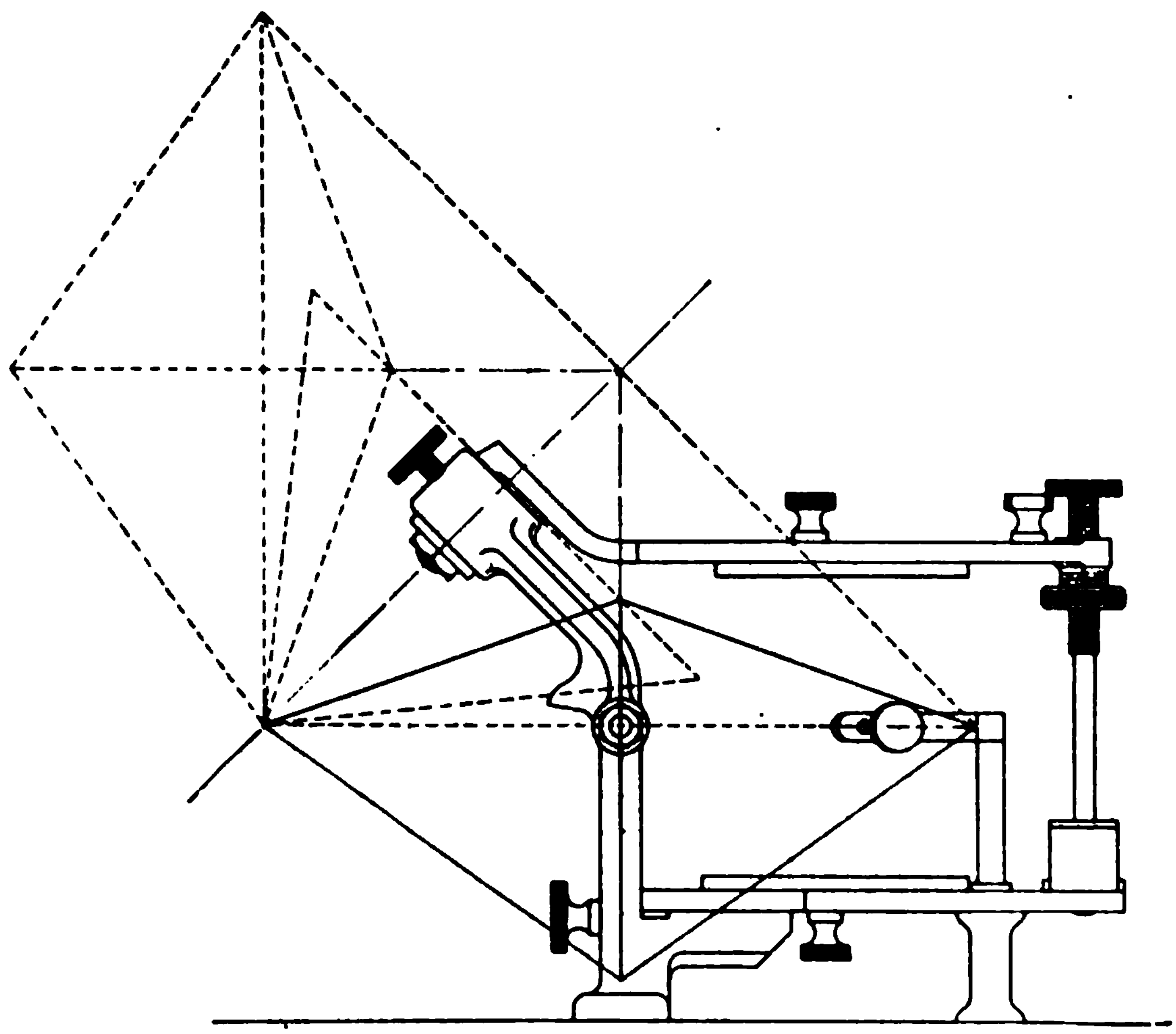

Fig. 140

Fig. 140 shows a diagram of the mechanical device for the registration and reproduction of these centers and movements. Fig. 141 shows a perspective view of the device. Practical description of the appliance is given in the Method of Use.

Method of Use.—Base-plates and wax occlusion models are prepared, trimmed, contoured and adjusted to the requirements of the case, but without special regard to the occlusal plane, as this will be established better in another way.

Secure the bite relation, mark the median line and the lip line, remove from the mouth and fuse the two waxes together securely with a hot spatula. Next, mark the curve of occlusion (curve of Spee), determining the position the teeth are to occupy. This curve normally should be equidistant between the upper and lower ridges; but it may vary if the absorption from the loss of the teeth has been unequal or if the esthetic

Fig. 141

requirements demand it. In all cases (the ridges permitting) the location of the anterior curve of occlusion will be determined by the intersection of the lip line with the median line, and the curve of Spee will blend or harmonize with the anterior curve. In the region of the first upper molar on either side indent the wax at the occlusal curve with a sharp-pointed instrument, and make a like indentation at the intersection of the median line and the lip line (Fig. 142). Next secure the

base-plates to the casts and attach the bite-jig *E* (Fig. 141), adjusting the screws in the indentations previously provided in the wax (Fig. 143). Next adjust the bite-jig, carrying the casts and bite waxes in the antagonizor, and attach the casts to the cast plates (Fig. 144). The bite-jig establishes the occlusal plane and Bonwill apex. Remove the bite-jig and the case is properly mounted and ready to receive the teeth.

FIG. 142

The centers of movement being theoretical and automatic, the dimensions and characteristics of the individual Bonwill triangle are of no importance; therefore no attempt is made to ascertain and establish them in the antagonizor. Exhaustive tests have proved that results without accurate dimensions are equal to those attained with them. Consequently, the face bow has been eliminated from use with this appliance and all cases are worked upon the theoretical average four-inch triangle. Therefore the design and use of the Hall antagonizor simplifies to an incomparable degree the technic and work in denture construction. The elimination of the need for measurements or adjustments makes the instrument the most simple and easy of understanding and operation yet devised.

Setting the Teeth.—Lock screw *A* (Fig. 141) is locked and the opening and closing movement is used for the initial or tentative setting. The teeth are arranged to conform to the ridges and to the esthetic requirements. Next they are tried in the mouth to ascertain the correctness of the bite and the esthetics, after which the trial dentures are returned to the

Fig. 143

antagonizor to adjust the teeth in their anatomical relations. The wax around the teeth is warmed, lock screw *A* is released and lateral movements are made, guided by the guide pin *B* in the center guide angle *C*. As pressure is brought to bear upon the teeth, they are automatically forced (applying the method of Gysi) into the correct anatomical relations. Next, lock screw *A* is locked and with adjusting screw *D*, the lower

teeth are thrown forward into the incisive relation, in which position they are adjusted to three-point contact or whatever arrangement is desired.

Lastly, they are returned to normal occlusion for final adjustment, after which the case is ready for waxing and vulcanizing.

Fig. 144

No attempt is made to perfect the occlusion and antagonization while the teeth are in the wax, because perfection gained at this stage would be lost in the succeeding operations of flasking, packing, and vulcanizing. It is better to approximate these relations as well as may be without grinding, and after vulcanization, when no slips or changes can occur, to

grind the teeth to occlusion and antagonization, after a corrected bite. This method consists in adapting a thickness of base-plate wax to the occlusal and incisal surfaces of the

Fig. 145

lower teeth, attaching it to the denture with a hot spatula, and inserting the dentures in the mouth and having the patient register the normal bite upon the wax carried by the lower denture (Fig. 145). Remove from the mouth and

Fig. 146

securely attach together in the relation established by the corrected bite as determined by the wax (Fig. 146). Adjust the bite-jig to the dentures the same as for the original bite

and remount in the antagonizor (Fig. 147). Remove the bite-jig and wax from between the teeth and the correct relation of the dentures is determined and the teeth are ready for grinding.

Fig. 147

Grinding the Teeth.—First, they are ground under the lateral movement of the antagonizor to the guide pin (*B*) center in the center guide angle *C*. Secondly, the lower teeth are carried into the incisive position by means of the adjusting screw *D* and the grinding under the lateral movements continued in this relation, bringing the lower teeth gradually back to normal occlusion with the adjusting screw as the grinding proceeds, effecting a solid cut with an unlimited

range that will accommodate all the milling, triturating mandibular movements, providing thereby accommodation automatically for varying rotation centers.

Dentures mounted in the Hall antagonizor may be placed in the mouth with the assurance that adaptability and coordination with the tissues and the mandibular movements will be perfect, with no points of interference, and no need of further cutting or adjusting. The teeth are ground in the antagonizor to perfect occlusion and antagonization in every direction it is possible for the mandible to move. Consequently, points of interference cannot be found, as there are

Fig. 148

none. Other antagonizors make no provision for the milling movements traced by the incisor point, and provide limited movements only to a definite given path for either side for each case. It is a well-known and admitted fact that the movements of the mandible are not restricted to definite paths, but it has been considered impossible to construct an antagonizor capable of reproducing all of the movements of the mandible. And an average movement only is all that has been accomplished or claimed for antagonizors of the past.

In the Hall antagonizor the supposed impossible has been

accomplished. The mechanism is such that all of the mandibular movements are reproduced and under perfect control of the operator. Its movements are capable of combining in infinite numbers of combinations, and teeth constructed in it have a like range of adaptability, insuring perfect coördination with the movements of the natural mandible when the dentures are placed in the mouth.

Fig. 149

Fig. 148 illustrates the correct anatomical relation of the teeth in lateral antagonization as interpreted and arranged by investigators and prosthetists at the present time.

Fig. 149 illustrates the incorrect relation of the teeth in lateral antagonization, according to the same authorities.

Dr. Hall's interpretation of these two illustrations is that diametrically the opposite is true, and he cites the fact that the relation shown in Fig. 148 provides no space for food, and when the antagonization is opened to receive food the balance

points are broken and the anatomics are *nil*. Therefore his contention is that we have had no anatomical antagonization; that the so-called anatomical antagonization has been in reality nothing but occlusion.

Fig. 150

With the Hall antagonizor the movements are such that normal overbite may be set and the teeth so arranged that the normal anatomical relations as shown in Fig. 149 may be secured as in nature (Fig. 150), and it is claimed to be the first antagonizor to permit of true anatomical arrangement of artificial teeth.

Having discussed at considerable length "other methods for anatomical antagonization" (see page 262), a return is made to the main subject of the chapter, vulcanite technic.

FINISHING THE MODEL DENTURES.

The teeth being now accurately mounted and antagonized, care must be exercised not to disturb them in any further manipulation. As the outlines of the wax-model bases are the outlines of the finished dentures, attention should be given to the contour of the wax-model bases. These are completed by adding wax where there may be a deficiency, cutting away excessive wax and glossing the surface. The Haskell and Gritman spatulas (4 and 5 respectively of Fig. 101) are excellent as ironing instruments, and the Nos. 1 and 2 instruments of the Evans carvers are especially suitable for carving. There are two methods for glossing—(1) heat, and (2) a solvent. The heat may be applied to glossing the surface either by passing the wax-model base through the Bunsen flame with a moderately rapid motion, or the flame may be puffed upon the surface of the wax with a small mouth blowpipe. An expert may produce beautiful results with the flame, but the novice is liable to come to grief. The solvent method consists of wiping the surface over with a soft cloth (quarter of an aseptic napkin) moistened with a wax solvent. The most convenient and least objectionable solvent is chloroform. The teeth are cleansed of wax at the same time that the surface is smoothed. As the surface is covered with partially dissolved wax, the case should be permitted to stand until the chloroform has evaporated. The evaporation may be hastened by using a blast of air.

Proving in the Mouth.—The artificial dentures are now ready for the third appointment with the patient. There are two phases of constructing artificial dentures to be given consideration at this sitting of the patient—(1) proving the occlusion and antagonization, and (2) developing the esthetics.

Proving the occlusion and antagonization is accomplished by placing the well-cooled model dentures in the mouth and requesting the patient to close the "back teeth," but force should not be used upon them, as they are only in wax. If they close in the retruded position, as constructed upon the

antagonizor, the inference is that the occlusion is correct. However, it is well to make other tests, as there is nothing about prosthetic dentistry quite so uncertain as how an edentulous patient may close the mouth. They are more liable to close it in a protruded position than in the normal retruded one. As a further test, the head is tilted backward, the prosthetist parts the lips slightly, and watches the result while the patient performs the act of deglutition. This act will necessitate the mandible being in its normal retruded position. Should the mandible drop backward an eighth or a quarter of an inch, the student may feel momentarily disheartened, for it will be necessary to go back and do the work all over again, beginning with the paraffin base-plates and occlusion and contour models. However, the student will profit by such an experience and henceforth give more attention to his occlusion and contour models. Should the deglutition test prove the occlusion in retrusion to be correct, the test for *equalized pressure* is applied. Before making this test it is better, as the wax has been absorbing considerable heat, to remove the model dentures from the mouth and again cool them. They are replaced in the mouth and just firmly held in retruded occlusion. An attempt is made to insert a thin-bladed spatula between the bicuspids and molars upon first one side and then the other. Should the pressure be even upon the two sides, well and good; but should there be a separation on one side, admitting the blade of the spatula, the blade should be rotated to determine the extent of the imperfection. If the imperfection is but slight, it may be corrected by removing the model dentures from the mouth, placing one in water to cool, drying the wax of the other (with absorbent cloth) about the non-contact teeth, softening the wax, extruding the teeth, and adding melted wax as indicated. The model dentures are returned to the mouth and closure made until equal pressure is obtained upon both sides. Should the separation upon one side be extreme, it is past correcting, and necessitates returning to the casts and beginning again. As the novice learns by experience, he will see that equalized pressure is an absolute necessity in the occlusion and contour

models, and this prevents the unequal pressure in the model dentures.

The model dentures, meeting the tests applied for retruded occlusion and equalized pressure, are placed in incisal occlusion and tested with the thin spatula for equal pressure at the three points of contact. The dentures are then consecutively placed in right and left lateral occlusion and tested with the spatula. The dentures meeting these tests are removed from the mouth, laved in cold water, dried, and returned to the antagonizor. As slight imperfections of occlusion and antagonization will be unconsciously corrected in the mouth, and may be apparent upon the antagonizor, it will be necessary to bring the antagonizor to the proved model dentures, and not the dentures to the antagonizor. The antagonizor is conformed to the tested model dentures in this manner: The upper cast is removed from the antagonizor, the model dentures and upper cast are assembled upon the lower cast, and the upper bow again attached to the cast with plaster. However, it is not necessary to conform the antagonizor to the tested model dentures unless it is desirable to make changes for cosmetic effects; then it is well to have a fixed record of the antagonization as developed in the mouth. It should be evident to the student that if all the procedures have been faultlessly performed up to the mouth test, no corrections will be necessary; but as there are so many sources for error, it is necessary for the most experienced and skilful prosthetist to prove the work at this stage of construction.

The second object of the third appointment is to develop the Esthetics. This phase of the subject will be fully treated in the chapter on Esthetics. The design in this chapter is to treat only the art and the science of construction.

CONVERTING THE MODEL BASE INTO VULCANITE.

The model dentures having been perfected are ready to be converted into their permanent form. This consists of substituting vulcanite for the wax. This conversion requires good workmanship and involves considerable science.

Synopsis.—Luting the model dentures to the casts; removing from antagonizor; flasking; opening flask; removing wax; heating; packing; closing flask; vulcanizing; removing from vulcanizer and flask; finishing.

Luting.—The model dentures are luted to the plaster casts by running a hot wax spatula (Fig. 101) along the peripheral border. It is essential to have the entire border luted so as to prevent the soft flasking plaster from getting between the model dentures and casts.

Fig. 151

Removing from Antagonizor.—The bows holding the casts are removed from the antagonizor frame. The plaster cast is removed from the bow by soaking in water for a minute or two, trimming away any luting plaster that may overlap the cast, forming a notch between the cast and luting, inserting a plaster spatula in the notch, and tapping with a light hammer.

Flasking.—The cast with its luted model denture is then adjusted to the vulcanite flask. The adjustment consists in seeing that the cast is neither too thick nor too wide for the flask; if such is the case, the cast must be reduced. This is done with a plaster knife (Fig. 67), after soaking the cast in water. Sufficient soft-mixed plaster is placed in the lower half of the flask to fill it half-full. The cast is then pressed into the soft plaster a sufficient depth to permit of the teeth being clear of the cover when the ring and cover are in place. Plaster is added to fill the space between the

edge of the base of the flask and the periphery of the model denture. The plaster must not be carried upon the model denture. When the plaster has set it is trimmed smooth with the plaster knife. Fig. 151 shows the case properly inclosed in the first section of the flask. The plaster being set and trimmed so that no portion overlaps the rim of the flask, a slope extending from the model denture to the rim of the flask, and care exercised that no form is given to the plaster to act as a key and thus interlock the two sections of the flask, the exposed surface of plaster is varnished with sandarac as a separator, or, a lather of soap is sufficient.

Flasking Upper Section.—As soon as the varnish has dried the surface of the porcelain teeth and wax-model base is wetted by holding in running water; this will favor the plaster flowing smoothly over the surface and filling the interspaces between the teeth. The model denture being wetted, the ring of the flask is set in place and a thick creamy mix of plaster of Paris is poured in to nearly half-fill it; the base and ring of the flask are so grasped as to hold them together while jarring on the bench, thus causing the plaster to settle into every interspace between the teeth. More plaster is added and settled in place by jarring. The third addition of plaster should fill the ring when the cover is placed and firmly pressed with the fingers, thus forcing out any excess plaster, which is wiped away.

Opening the Flask.—The filled flask should stand until the plaster is hard set (thirty minutes). It is then placed in a three-quart stew pan and covered with cold water. The pan is placed upon the gas stove or large laboratory heater and heated until the water begins to boil, when the flask is removed from the water (use flask tongs, Fig. 113, or holder of Buffalo No. 2 press), and held in the left hand protected with a cloth holder. Start the separation of the two sections of the flask by inserting the edge of a plaster knife between them. As soon as the two sections loosen, the upper section is grasped with a cloth holder and carefully drawn apart, care being exercised to so manipulate the two sections as to release them of any slight interlocking. The rule for placing the knife for starting the separation is:

For upper cases place the knife at the heel of the flask, and for lower cases at the toe of the flask. This will prevent fracturing the overhanging anterior alveolar ridge.

The instruction given for heating in water is subject to much variation. The object is to apply heat in such a way as to soften the wax without melting it. It is evident that some judgment is necessary, as there are several factors, such as amount of heat, water, and plaster about the wax. A little experience and observation will enable the prosthetist to closely estimate the time to open the flask.

Another method is to have the water boiling and submerge the flask for one to three minutes. The time is inversely to the thickness of the encasing plaster about the wax, and the desired softness. The author has recently come to prefer this method. He uses one quart of boiling water, which is removed from the stove, into which he submerges the flask long enough to soften the wax sufficiently to avoid danger to the contents of the flask. Usually one minute is enough. This short time will soften the wax but slightly. Wax melted into the cast is detrimental to vulcanite.

Removing Wax.—The softened wax is removed from the parted flask with a wax spatula so far as possible, and the remainder removed by a stream of boiling water. (A small teakettle is excellent for this purpose.) By examining the parted flask it will be seen that the cast is in the bottom section of the flask, and the teeth, with their cervical ends exposed, are in the upper section. If any plaster has found its way about the pins and cervical ends of the teeth, where there should be none, it should be removed with a pointed instrument and brush. Excess space should be cut about the periphery of the plaster, *but without gateways*.

Heating.—The upper section of the flask is placed upon an 8- or 10-inch square piece of sheet iron over the gas stove, as shown in Fig. 152. While inspecting the upper section of the flask, the lower section is placed under the sheet iron, as seen in Fig. 152, to be dried by reflected heat. During the three or four minutes that the upper section is warming, the surface of the cast in the lower section of the flask is given attention. The surface of the cast should be treated so that

it will impart a dense and smooth surface to the vulcanite. There are two methods for accomplishing this—(1) painting the surface with a liquid finish, and (2) covering with tinfoil.

The Silex Method.—The liquid-silex method has the advantage of being easily applied, and, if the surface of the cast is entirely free of wax or oily substances, will give good results. A clean ox-hair or camel-hair brush is dipped into the iquid silex and is then applied to the cast. It will be necessary to occasionally dip the brush into water, so that

Fig. 152

the silex may be well diluted and evenly applied. The excess silex should be absorbed with a cloth. Another method is as follows: While the thin silex is still moist upon the cast, dust with talcum powder, and, when dry, rub carefully with a soft cloth. The liquid-silex bottle should be kept well corked and no particles of plaster be permitted to get into it, as they will precipitate and spoil the silex for its intended use. The brush must be well washed each time it is used.

The Tin Method.—This method is preferable because it gives a smoother and denser surface to the vulcanite, espe-

cially if any wax has been melted into the cast. A sheet of No. 4 tinfoil (0.0005 of an inch thick) is fitted over the cast with the thumb and finger. It is then removed and the excess tin cut away with sharp scissors, as indicated by the imprint of the edge of the cast upon the tin. The cast is now coated with sandarac varnish, and when it has dried to tackiness the tin is at once replaced and firmly pressed and gently rubbed with a wad of soft paper until there is perfect adaptation to the cast. The tin should be rubbed until it has a well-burnished surface. It is important that the *tinned cast be coated with a lather of soap.* This is accomplished by wetting a soft-bristle brush and rubbing it upon a cake of soap and then upon the palm of the hand until a smooth lather is formed, which is applied to the tinned surface; or, a thin wash of Johnson's ethereal soap may be used. If the soap is not applied the tin and vulcanite will adhere very strongly, and can only be separated by dissolving the tin with mercury or hydrochloric acid.

The cast, having been coated with either silex or tinfoil, is replaced under the sheet iron to be warmed while packing, the rubber into the upper section of the flask.

Packing the Rubber.—During the time the flask is being heated preparatory to separating, the rubber is stripped of its cloth covering and cut into suitable form for packing. For the upper case a piece of red rubber is cut of sufficient size to cover the central portion between the teeth; and the remainder of the red rubber, required for either the upper or lower, is cut into strips, across the sheet, about one-half inch wide. Sufficient pink rubber, or Walker's granular gum, to face the labial and buccal surfaces of the case is cut into the same-sized strips, also thirteen small pieces (triangle or square, form indifferent, size about one-fourth inch) are cut for packing between the teeth. For convenience of handling, the cut rubber may be placed upon a porcelain plate or a piece of glass. As rubber is very cohesive, the pieces must not touch each other while on the receptacle. As the flask is heated, it is unnecessary to heat the rubber; in fact, the cold rubber can be much more conveniently handled than that which is warm and adhesive. The heat

of the flask will sufficiently soften the rubber to cause it to pack easily. Care should be exercised not to overheat the flask. It should be about the temperature of boiling water, or lower. As rubber melts at 250° F., and its quality is impaired when melted if exposed to air, it is well to have a safe margin of 40° or 50°. Two instruments, one in each hand, will be required for packing the rubber. Any small and blunt instrument may be used. A small flat-blade burnisher held in the left hand to stay the rubber while packing, also useful to carry the small pieces between the ends of the teeth, and the Zurbrigg rubber packer (Fig. 153), or the No. 3 instrument of the Evans set (Fig. 100) are admirably adapted as packing instruments. A narrow strip of red rubber is placed along the pins of the teeth, and as the rubber softens is pressed against the pins with the flat side of the broad end of the packer. The pins of all the teeth being

Fig. 153

engaged in the red rubber, one of the small pieces of pink rubber is engaged in each of the spaces between the ends of the teeth. Packing these small pieces is simple and expeditious; however, a novice is liable to waste much valuable time in its performance. The small pieces of rubber are carried on the pointed end of the No. 3 instrument to place, the edge of the burnisher, held in the left hand, carries it between the teeth, and while so held the packing instrument is used to turn one edge over upon the center of the space between the teeth and compress the rubber while withdrawing the other instrument. These three movements to each space should be sufficient. A strip of the pink rubber, sufficiently wide to nearly cover the buccal and labial surfaces of the denture, is placed with one edge overlapping the teeth for about one-half their thickness. The fingers are then used to compress the strip of rubber down upon the ends of the teeth and against the sides of the plaster mold. This act unites the large strip

and the small pieces and perfectly forms them about the cervical ends of the teeth. If much restoration is required for the gum portion, another layer of pink rubber may be placed upon the adjusted piece. However, the edge of this piece should not overlap the teeth, but extend from the teeth to the margin of the mold. If there is great thickness of gum restoration required, pink rubber should be added to nearly complete it. The reason for making heavy restorations with pink rubber in place of the stronger red rubber is: There is no danger of thick masses of pink rubber vulcanizing porous, while the same space filled with red rubber is almost certain to do so. If a thin gum restoration is required, one layer of pink is sufficient. The next step in packing the upper case is to place the center piece, which is done by adapting the piece of rubber to the plaster matrix by finger pressure from the center outward, permitting the edge to overlap the packed rubber. In the lower case one or two thicknesses of red rubber is placed upon the lingual surface of the mold. The packing of rubber is done with the fingers when possible, only using instruments where the fingers cannot effectively reach. The problem confronting the workman at this stage of the operation is to know when sufficient rubber has been placed to just fill the mold, for much excess rubber is liable to do harm. Various methods are used, as: Weighing the wax model plate and taking its weight plus one-fifth in rubber, the difference in specific gravity. Displacement method: Place the wax of the model plate in a suitable dish (glass tumbler) and fill it to overflowing with water; the wax is removed and replaced with rubber. With either of these methods a little extra rubber should be added and good judgment used in distributing the rubber in packing. The preferred method is the "Trial" method.

Closing the Flask.—This (trial) method consists of placing the rubber in the mold as has been described, until the judgment dictates there is nearly but not enough to fill the mold. A piece of close-woven cotton cloth, free from starch, is saturated with water (preferably hot) and placed over the packed rubber; the two sections of the flask are put together

and carefully closed in the flask press. The flask is then opened and the cloth removed, when it will be apparent where more rubber is required and the quantity. Should so large a quantity of rubber be required that it is questionable when a sufficiency has been added, a trial with the wet cloth may again be made. When the mold is found to be full, the flask is closed without the cloth. (The cloth stripped from the rubber and washed of its starch may be used, but dress lining cut in pieces 3 by 3½ inches is better and saves valuable time. Should the cloth, for any reason, adhere to the rubber, saturate it with hot water, when they may be easily parted.) Attention has been called (page 224) to the danger of warping the denture by improper placing of the rubber and heavy pressure in the press. Should the rubber in the mold become too cold, it may be carefully warmed by reflected heat under the sheet iron, or the rubber-packed flask may be put in water and boiled before the final compression in the press; however, the softening that takes place in the saturated plaster favors warping the denture. Undoubtedly the "fit" of more artificial dentures is impaired by improper packing and closing the flask than by all other causes. The flask being closed is placed in a Donham clamp (Fig. 104), either with or without the volute spring.

Vulcanizing.—The method and philosophy of vulcanization have been discussed under the physical and chemical properties of vulcanite, in this chapter.

Résumé.—If the case has been properly flasked, packed, and clamped, the gas regulator should be set at 320° F., for approximately 80 minutes.

Study well the philosophy of vulcanization.

Perfected Method.—In the preceding pages stress has been laid upon the method usually taught by the schools and practiced by the profession. Now the author desires to present the method that he believes is scientific and produces the best vulcanite results.

The model denture is constructed upon a hard plaster compound cast—tinned and flasked.

For best results the flask should be kept out of water until after vulcanization, as water softens the plaster and favors

warpage of the denture. The investment plaster should set for one-half hour or longer. It is then placed in the Sargent Electric Drying Oven to warm and soften the wax, but not to melt it. The Electric Oven (Fig. 154) is a most valuable adjunct to the dental laboratory; however, it is not now in the dental supply house, but can be procured by them. It is a chemists' apparatus and is manufactured and sold by E. H. Sargent & Co., 155 to 165 E. Superior St., Chicago, Ill. The heat can be adjusted to any degree up to 00° F. If the temperature is set at 220° F. it will be safe for any purpose the prosthetist may desire a low temperature heating appli-

FIG. 154

ance. An Interval Timer, as the Victor Electric (Fig. 155) is also a very convenient instrument for many places in the laboratory. It can be set for a few seconds or any time up to two hours. The alarm is sufficiently long (not too long) and loud to be heard anywhere in a small office. It relieves the prosthetist of much responsibility. A little experience will enable any one to determine the exact time to accomplish a desired result. The length of time that will be required to soften the wax the desired amount must be learned experimentally for each office. The time required will be from five to twenty minutes, too long a time to watch or with which

to tax the memory. Should the wax be overheated it may be washed out with a quart or two of boiling water, in which

Fig. 155

Fig. 156

a dessertspoonful of sal soda has been dissolved. The sal soda emulsifies the wax and better disposes of it. An excess

space should be cut as shown in Dr. Snow's illustration (Fig. 156). Notice there are no notches or vent spaces cut from the mold to the excess space. This method shuts in and retains the required rubber. The flask is then placed in the drying oven for ten minutes to dry and warm. The investment plaster should never be so hot that the fingers cannot be held upon it with some pressure. The case is packed by the separating cloth method. When the case is packed there should be 5 per cent. excess rubber in the flask. In other words, the mold should be full and the flask not quite closed 0.5 mm. separation. If the flask is not closed enough it may be placed in the flask press (Fig. 107) and placed in the warming oven by removing the two upper shelves, which are rarely needed by the dentist. Or, the flask may be placed in the press of the Snow Compensating Vulcanizer and 200 pounds spring pressure applied and placed in the pot, without tightening the bolts, and boiling for a few moments. The flask will be in the steam only. The vulcanizer cap can then be lifted from the pot and if the flask is properly closed the spring pressure is removed from the flask and the case or cases (one, two or three) placed in the vulcanizer and it properly closed for vulcanization. The gas regulator is set for 270° F. and the full heat applied for ten or fifteen minutes, depending upon whether the vulcanizer was hot or cold, and 500 pounds spring pressure applied. The blow-off may be opened and the air expelled. The vulcanizer is then made steam tight and held at 270° F. for twenty minutes. The gas regulator is then set for 280° F. and permitted to stand twenty minutes, when it is set for 300° F. As the regular vulcanizer clock should have been set for three hours when starting the vulcanizer, the operation will consume one hour in raising the temperature to 300° F. by the thermometer and will hold that heat for two hours, the required time for vulcanization. The vulcanizer should stand until it is stone cold before it is opened; it is best to have at least eight hours. This permits the molecular set of the vulcanite and removes the greatest source of danger from warpage of vulcanite dentures. The prosthetist nor

the patient never should place a vulcanite denture in water hotter than the hand can be held in all the time the denture is in it. The danger of warpage begins at about 130° F.

FIG. 157

The former method detailed will give a fairly good vulcanite but not the best. The slow vulcanization undoubtedly gives the best results, but it requires special apparatus to produce these results economically. The Snow Compensating Vulcanizer (Fig. 157) is the latest and especially constructed to meet modern requirements. This vulcanizer is modeled

after the Edson (which is the next to the best), it has resilient springs in the heads of the yoke, registered from 100 to 800 pounds. The cap is bolted on (not screwed on) and is large enough for modern demands. It is well made, has the usual safety valve and an especially efficient blow-off. The operation described with this vulcanizer is very simple provided the operator uses an Interval Timer, which takes but a moment and relieves the mind of responsibility and permits giving attention to other work. The reason that rapid vulcanization was advocated for the old method was that shrinkage of the vulcanizing rubber could be better controlled, but with the compensating vulcanizer an excess of rubber may be added at the proper time by simply adding spring pressure. It is a known fact that the best vulcanization is produced at not to exceed 320° F. actual temperature (75 pounds steam pressure) which is 300° F. by the thermometer set in a mercury bath. (The gas regulator is adjusted to read with the thermometer.) The thermometer reading 320° F. is actually 340° F. or 100 pounds steam pressure. This high heat damages somewhat the texture of the vulcanite. Even a higher heat is often inadvertently used and produces a very brittle vulcanite.

Removing from the Vulcanizer.—It is always best to permit the vulcanizer to stand until it is cold before opening, but when it is necessary to expedite matters the steam may be blown off, the vulcanizer opened, and the flask submerged in a pan of cold water. This last procedure would be condemned by some, but owing to the poor conducting and radiating property of plaster, it is doubtful if this method of cooling ever accounts for fractured teeth. However, the effect upon the vulcanite is conjectural, not having been determined experimentally.

Removing from the Flask.—Under no conditions, however, should the flask be opened until the plaster in the center of the flask is cool, which will be some time after the flask is cold if placed in water. The flask is released of its clamp, held in the left hand, with the plaster knife in the right hand. The knife, guarded with the thumb so that only a quarter- or half-inch is exposed, is used as a wedge to part the sections

of the flask. Usually the case will remain in the ring portion of the flask, and is removed by cutting a groove in the encasing plaster between the denture and ring. The plaster both on the inside and outside of the denture is grooved and removed in sections, thus avoiding the danger of fracturing the denture. The last portions of the plaster not easily removed with the knife are removed by scrubbing with a stiff-bristle laboratory brush and water.

Finishing.—The edges of the denture as it comes from the flask are rough and irregular from the extension of excess vulcanite. This is removed with a rather coarse file specially made for this work (Fig. 114). A seven- or eight-inch half-round file, having an oval and a flat side, a coarse and a fine end, is a very desirable instrument. The cutting is done with a push stroke. A round or rat-tail file is also very useful. For scraping the surfaces the No. 1 short-shank Kingsley scraper of the Wilson vulcanite finishers is used. The No. 4 instrument is useful for small places, and especially for removing defects on the maxillary and mandibular surfaces. The chisel (No. 2 of this set) is for carving about the teeth, and the pick (No. 3) is for working between the teeth (Fig. 115). These instruments should be kept very sharp by grinding and honing. The entire labial, buccal, and lingual surfaces of both upper and lower dentures are gone over to remove excess material, give form, and to remove the roughness received from the plaster matrix. The file and scraper marks are removed with sandpaper. No. ½ for coarse paper and No. 00 for fine paper is cut into two and one-half inch squares, by placing the sand side down over a crevice and cutting with a knife. The sandpaper marks are removed with buffers and glossers (see pages 242 to 244). The maxillary and mandibular surfaces require no finishing except to remove any excrescences formed as a result of air-bubbles in the surface of the cast. These are carefully removed with the small scraper. This surface may be more highly glossed by using the soft-brush wheel and whiting. The finish grinding (see page 254) of the occlusal surface of the teeth is executed with small stones mounted on an engine mandrel and carried in the lathe chuck.

The object sought is to deepen or reproduce the sulci and grooves, thus forming edges to cut the food in the process of mastication. The ground surfaces of the porcelain teeth are given their final finish with a piece of No. 00 sandpaper applied with the ball of the thumb. The finishing of any mechanical work is an important item, and in artificial dentures is not only indicative of superior workmanship, but is necessary for cleanliness and health of the tissues with which it will be in contact. Fig. 154 illustrates the completed dentures.

FIG. 158

Inserting the Finished Dentures.—The fourth appointment with the patient is a very important one. The dentures are inserted and the adaptation in every respect inspected. The dentures are wonted to their place by closing the teeth and swallowing; this settles and withdraws the air from beneath them. If the dentures are evenly seated, so that pressure may be made upon any part without being disturbed when opening the mouth and by the ordinary movements of the lips and tongue, and do not cause pain, and the occlusion and antagonization are correct, the patient should be instructed how to use and cleanse them. The patient should be instructed to keep the dentures in night and day, only removing for cleansing, until they have become masters of the artificial substitutes, after which the dentures may be removed at night, cleansed, and kept in a weak solution of boracic acid. The patient should be

instructed that if the dentures cause pain, they are not to be removed from the mouth, but that the patient is to return to the office for attention.

THE CONSTRUCTION OF EITHER AN UPPER OR LOWER DENTURE.

The technic involved in the construction of either an upper or lower denture varies from that of both upper and lower in a few of the processes. As the technic for constructing an upper denture to natural lower teeth is the same as constructing a lower denture to natural upper teeth, or *vice versa,* it is necessary to describe but one, as the description of either would be the same as the other except in the use of the terms upper and lower, which would be transposed. For convenience of description the imaginary patient has an edentulous upper jaw with a full complement of normally aligned lower teeth.

The mouth is carefully examined and the conditions observed. A scheme is devised for taking the impression according to the indications, a suitable cast and the upper occlusion and contour model formed. The processes of construction are the same as described for the complete upper and lower case up to forming the occlusal surface of the wax model. As in the former case, the occlusal surface of the anterior portion of the model must mark the length of the upper lip when at rest and relaxed. The occlusal surface of the model as it extends backward must have at least three widely separated points of contact with the lower teeth. The patient is then exercised in the forward and backward or protrusion and retrusion movements of the mandible. The wax model is then removed from the mouth, cooled, and dried. With a roll of soft wax placed upon the occlusal surface of the model, it is returned to the mouth, and the mouth closed in the retruded position, biting the teeth through the soft to the hard wax. The wax model is removed from the mouth and a wax impression taken of the lower teeth. The imprint of the lower teeth in the wax model will not suffice for the impression. The wax impression is

taken by placing a roll of well-softened yellow wax in a warmed, sŭitable size, flat-floor lower tray. A good impression should be obtained of the occlusal surfaces and at least one-half of the length of the teeth. The impression of the cervical half of the teeth is indifferent. The impression is filled with plaster or, better, Spence compound. When the plaster is hard set, the tray is removed by warming in the Bunsen flame and lifting it away from the wax. The wax will be somewhat softened in removing the tray, and may be further softened by passing through the flame. It is removed from the cast by turning the buccal and labial surfaces of the wax upward and inward to the lingual side, when it may be easily removed from the cast. The upper cast, wax-occlusion model, and lower cast are then assembled and mounted upon an occlusion frame or an antagonizor to be used as an occlusion frame. The student should be impressed with the fact that the casts so mounted are in no way to have their relationship changed without removing from the frame and remounting. It is hardly necessary to use a face bow in mounting a single case upon an antagonizor, as the occlusion is established, and, except in rare cases, it is not justifiable to alter these natural teeth. However, the face bow may be used if desired, in the same manner as for the full upper and lower dentures. A case so mounted permits of opening or closing the bite, but this will not be necessary if proper attention was given to forming the wax model. Then, again, if the case is mounted with the face bow, interfering cusps may be more easily detected.

The teeth must be ground and set up so that the molars and bicuspids intercuspate and the six anterior teeth are free of contact. As it is a rare instance that a full upper denture will be required and the patient have a full set of normally aligned natural lower teeth, it becomes necessary to give special attention to the occlusion. The law of force and the law of the resultant of two or more forces must be taken into consideration, or the completed denture will be very deficient. The rule is to have the force or the resultant of two forces act at right angles to the normal occlusal plane. However, it is permissible and often desirable to

have the line of force, acting upon a full upper artificial denture, slightly distal to the perpendicular. This is accomplished by having a greater stress upon the mesial than upon the distal facets of the upper teeth. The teeth being properly occluded (leaving the antagonization to be attended to at the time of fitting in the denture), the construction is completed the same as in the case previously described.

PARTIAL DENTURES ON VULCANITE BASE.

It is a truism that the difficulties of constructing artificial dentures are in direct ratio to the number of teeth to be supplied. The technic of constructing a partial vulcanite denture for either jaw is the simplest prosthetic procedure (however, the fitting in or adjusting to the mouth is more difficult than any other vulcanite denture); either a full upper or lower is more complicated, while the complete upper and lower present the greatest problems of prosthesis.

A perfect plaster impression (see Chapter II) should be obtained to inclose a little larger surface than the base-plate is designed to cover. Usually an occlusion cast of the opposite teeth is required; however, if there are no opposing teeth an occlusion cast will not be necessary. In some partial cases the two casts will have so many points of contact that they may be assembled without further aids. A quash-bite will suffice for some cases, while for others a well-constructed occlusion wax model may be a necessity. The case is placed in an occlusion frame, a wax base-plate formed, and teeth of color, form, and size to correspond with the remaining teeth in the mouth are selected. They may be ground to favor adjustment, also to obtain the required occlusion. It is a safe rule to establish that all artificial dentures, both full and partials, should be adjusted to the mouth while in the pattern; nevertheless there is a class of partials that often (not always) are exceptions to the rule. The class referred to is where teeth and spaces alternate. Those partial cases that cannot profitably be tried in the mouth in the pattern will probably require much skill and time in adjusting the completed piece. The wax-model plate being contoured, the

cast containing it is removed from the occlusion frame. The rule for flasking full cases is: The separation of the two sections should be at the peripheral edge of the wax-model plate. This rule applies to some partial cases. In these cases the plaster teeth should be cut down flush with the wax-model plate and the encasing plaster built up to the top of the stumps of the plaster teeth. These reinforced stumps must be so shaped that they will easily draw from the mortise they form in the upper section of the flask. There are many partial cases in which the porcelain and plaster teeth so alternate that it is better to encase the teeth in

Fig. 159

the first section of the flask. It is obvious that the packing of such a case must be from the lingual aspect. Fig. 159 illustrates an upper model denture without labial gum restoration. Fig. 160 is the case in the first section of the flask, and illustrates the method of flasking where plaster and porcelain teeth alternate.

The tinfoil used to finish the maxillary or mandibular surface is applied before placing the base-plate wax, because it will be difficult to adapt the foil in the flask. The soap solution is applied after the wax is removed, just prior to packing. Careful manipulation will be required in the

various procedures not to disturb the finishing tin. The liquid-silex method is useful in many partial cases.

Partial cases are vulcanized the same as full ones.

Care should especially be exercised, in removing the case from the flask, to have the plaster cold, and in the use of force.

The finishing process consists of filing, sandpapering, buffing, and glossing, and are essentially the same as for full cases.

FIG. 160

Adapting the finished cases to the mouth is, as has been stated, a difficult and often a perplexing operation. It will frequently require careful study and manipulation, and often much trimming away of the base-plate as formed. However, this trimming must be judiciously performed, because as close an adaptation and as large a base of support as possible is imperative. Partial cases may require a high degree of mechanical ability, but complete dentures will require mechanical dexterity and esthetic sense.

The retention of artificial dentures has not been mentioned

in discussing the technic of vulcanite construction, for the subject is more comprehensible when considered in the abstract.

REMOVING THE TEETH FROM A VULCANITE BASE-PLATE.

Sheet-iron Method.—Place the denture, teeth downward, upon the sheet iron over a gas stove, and when the vulcanite is thoroughly softened the teeth may be pushed off one at a time by inserting the wax spatula between the tooth and the vulcanite upon the lingual side. The plate is held by a pair of pliers and the dislodged teeth are permitted to fall upon wood, or, better, upon cloth, but not upon cold iron or stone. Any portion of the vulcanite remaining about the pins should be removed. If necessary, these small portions of vulcanite may be softened by grasping the tooth in a pair of solder tweezers and holding in the Bunsen flame.

Glycerin Method.—The denture is placed in a vessel of glycerin and heated to the boiling-point of the liquid, when the teeth can be removed as in the other method. The glycerin is soluble in water and easily removed. The fumes of the heated glycerin are more objectionable to some than those of the overheated rubber.

Flame Method.—The denture is grasped with a pair of pliers and the outer surface of the teeth heated by passing repeatedly through the flame until the vulcanite is softened about the pins, when they are removed as before described.

It is not advisable to remove the teeth by heat from a denture which is to be used again, because of the liability of warping the plate. In such cases the vulcanite should be cut from about the pins of the tooth with a burr in the engine, or with a chisel.

REPAIRING VULCANITE DENTURES.

The breaking of vulcanite dentures is usually due to over-vulcanizing, by which elasticity and toughness are destroyed; to improper arrangement of the molars, by which the strain

of mastication is thrown on the outside instead of on top of the ridge; or to a warped plate. The first evidence of the giving way of a piece is usually a fine crack appearing between the two central incisors, and sometimes, in partial dentures, in the border surrounding a natural tooth.

Wax Method.—A method particularly applicable to plates which are broken entirely in two consists in adjusting the two parts of the plate together, and fastening them in correct relation to each other temporarily by adhesive wax dropped on the lingual surface so that plaster can be run into the maxillary portion of the denture. As soon as the plaster hardens, the plate is removed from the cast, the line of division is enlarged with a file, and dovetails cut opposite each other with a jeweller's saw, as shown in Fig. 161. The dovetailed space is then filled with wax, invested in the usual way in a flask, packed, and vulcanized. By another method the edges may be adjusted as before described, and the piece be placed immediately in the lower half of the flask. After the plaster has set, the adhesive wax is to be removed from the lingual side of the plate and a line cut with a round engine burr along the full extent of the crack, or break, half-way through the plate and a quarter of an inch wide, with smooth regular edges, without dovetails. The case is then waxed up and the other half of the flask poured, when the case is packed and vulcanized. If the parts have been kept perfectly clean, the union will be quite strong.

Another modification,[1] which gives the best results, is this: After the cast is made, the portions of the plate are removed from the cast and with file and scraper a long bevel is cut, forming a thin, feathery edge along the fractured edge and sloping away from this for an eighth to a half-inch as the case will permit (Fig. 162). The pieces are then filed to give a slight bevel upon the maxillary surface. The portions of the plate which have been cut away are replaced with wax, and if necessary the plate may be thickened over the portion having the freshly cut surface. It is unnecessary to coat the vulcanite surface with a solution of rubber, as

[1] The method preferred by the writer.

the heat and pressure will make the union. Fig. 163 shows method of flasking.

In this connection, attention is called to a class of repair

FIG. 161

FIG. 162

cases that perplex the novice; namely, those having an extensive fracture upon both the lingual and buccal or labial surfaces. This difficulty in flasking is overcome by attaching one or more shafts of wax, one-fourth inch in diameter, at suitable locations over the fracture upon the labial or buccal surface. The shaft of wax must be sufficiently long to extend through the investing plaster. When the plaster has hardened, a portion of the wax shaft and the surrounding

Fig. 163

plaster is cut away to form a cone-shaped depression, which will be filled in with the plaster in the top section of the flask. These wax shafts will form openings through which the rubber can be packed, and which are to be filled with rubber. After vulcanization the shaft of rubber may be removed with a mechanical saw.

Fusible Metal Method.—To avoid loss of strength by the second vulcanizing it is recommended that fusible metal, melting at 150° to 160° F., be used to fill the dovetailed space.

This can be done by pouring the melted alloy into the space and packing it with a hot spatula, which is readily admissible owing to the low fusing-point of the metal. While the method has the advantage of not requiring a second vulcanizing, the union of the metal at the point of fracture is not as close as when rubber is used, and it cannot be said to be reliable as a means of repairing broken vulcanite plates.

A single tooth may be fastened to the vulcanite by filing the dovetailed space as for repairing with rubber, the fusible metal to be put in place with a hot spatula; or the dovetail can be filled with amalgam.

FIG. 164.—Plate prepared for the addition of several teeth.

Ironing-in Method.—This method is suitable for replacing a tooth or two, or filling a short crack or a hole. The vulcanite is cut with a file to give a dovetailed form to the space into which a tooth is to be added; and a crack or hole should be prepared for the new rubber with a scraper. The new rubber is ironed into place by using a hot wax spatula and firm pressure.

Replacing Vulcanite Method.—Much the better way is to fasten the parts together, run a plaster cast into the denture, then make a bite of plaster to serve as a guide for the replacement of the teeth, remove the latter from the broken plate, reset them to the cast, wax up the piece, flask, and vulcanize. This affords practically a new case, and the time consumed

is not much greater than is required in repairing the old one.

Additions to Old Plates.—Additions of teeth to old plates are accomplished after practically the same methods. Fig. 164 shows a case where four teeth have been extracted, and the old plate is prepared for the addition of as many porcelain teeth, so that the denture could be worn until the resorption of the alveoli and gums would admit of the construction of a permanent plate. The illustration shows the plate bevelled off to a smooth edge, and several holes drilled into the filed portion. The correct occlusion of the new teeth is obtained by placing the plate in the mouth after the bleeding ceases, placing two pieces of softened wax along the alveolar ridge and plate, and directing the patient to bite into the wax, and then gently pressing the wax while the teeth are in contact. This gives the correct relation of the lower to the upper teeth, and the impression of that portion of the alveolar ridge to be covered by the addition to the plate. The preparation of the plaster cast and bite is done in the usual way, plain teeth being ground to the gums to allow for the rapid resorption which always follows the extraction of teeth. The waxing and flasking are done in the usual way.

CHAPTER VII.

PRINCIPLES OF RETENTION OF ARTIFICIAL DENTURES.

The retention of artificial dentures is purely mechanical, and is based upon the laws of physics. Indirectly, however, the personal equation is an important factor, in that the patient may not be able to control the laws of physics. These vexatious cases are often spoken of as awkward or clumsy, but such patients will eventually succeed in overcoming the difficulties, provided they have sufficient perseverance.

The physical laws that play a more or less important role in the retention of artificial dentures are atmospheric pressure, adhesion by contact, leverage, tensofriction, and cementation. These forces are not equal in value, nor can any one principle be depended upon for retaining a denture. There will be a primary selected to bear the burden, and one or more secondary forces evoked or unwittingly included. These secondary forces may be either positive or negative. Thus atmospheric pressure may be selected as the primary retentive force, but adhesion by contact must be an associate retentive force, whether it be so designed or not, and eventually will entirely take the place of atmospheric pressure in any given case. The principle of leverage is always associated, through antagonization, with whatever may be the primary method selected. This force especially may be considered as positive when the arrangement of the teeth is such that it tends to force the denture more securely to place, and as negative when the arrangement is such that antagonization tends to loosen the denture.

Atmospheric Pressure.—As is well known, atmospheric pressure is the weight of a column of air resting upon an

object. The weight of a column of air at the sea level is 14.7 pounds to the square inch, and decreases in ratio to the height above sea level. As this pressure is equal in every direction upon and within the human body, it is not perceptible. Whenever a portion of this column of air is removed from a circumscribed portion of the body, its effect is immediately felt. No substance can be placed between the atmosphere and the surface, or a portion of the surface, of the body, and remove the pressure of the atmosphere from the body, as the intervening substance, being contiguous, would be held against the surface of the body by the full weight of the column of air resting upon it. Thus we may justly conclude that an artificial denture perfectly adjusted to the tissues of the mouth would be retained by the full weight of the column of air, or approximately fifteen pounds for each square inch of surface covered; also that a chamber cut in the maxillary surface of the plate would be a positive detriment, because it would be an air chamber equalizing the column of air upon the external surface of the plate to the extent of the air chamber. However, there is a fatal obstacle to this imaginary retention of an artificial denture, for it is a physical impossibility to exclude the film of air between the soft tissues of the mouth and the hard base-plate except by substituting a fluid for the film of air. By the substitution of this fluid for the film of air the law of hydrostatics is introduced. The law of hydrostatics is, that a pressure placed upon a confined liquid is equal in every direction. Therefore a mechanically perfectly adapted artificial denture having a fluid contact cannot be retained by atmospheric pressure, because the intervening fluid equalizes, within and without, the atmospheric pressure.

Atmospheric pressure *may be utilized* to retain an artificial denture, but through the medium only of a vacuum chamber. Since an absolute vacuum is an impossibility, the amount of retention by atmospheric pressure is contingent upon the area of the chamber and the vacuity obtained. To produce any degree of vacuity it is necessary to have the plate surrounding the vacuum cavity perfectly adapted to

the soft tissues. The extent of exhaustion of the air from the chamber is governed by the power of the muscles of the tongue and the ability of the patient to apply them. The exhaustion is produced by forceful swallowing.

Retention by atmospheric pressure can only be temporary, and maintained only so long as there is a partial vacuum. The effect of the vacuum chamber upon the tissues of the mouth is the same as cupping in medical practice. As soon as the atmospheric pressure is reduced upon a circumscribed portion of the body, it acts as an excitant, causing an increased blood-pressure in the part with a temporary swelling, and if continued a proliferation of tissue cells producing a permanent growth until the chamber is filled. When the chamber is filled by tissue and the fluids of the mouth, atmospheric pressure can no longer exist; the denture is then retained only by adhesion by contact. While the term "suction plate" is not so euphonious as "atmospheric pressure plate," it more nearly expresses the truth without attempting an explanation of how the suction is secured.

As the amount of retention of a vacuum chamber stands in direct ratio to its area, so its relative permanence and its injurious effects stand in direct ratio to its depth.

Emergency Vacuum Chamber.—There is a form of vacuum chamber that may be called the emergency vacuum. It is invisible and exists only during an emergency. It is best illustrated with a full upper denture. It is also efficient in favorable full lower dentures. This emergency vacuum is conditioned upon areal contact, peripheral adaptation and extension upon yieldable soft tissue. In full upper cases the essential extension is the *entire* length of the palatal border. This palatal border bearing upon yieldable tissue must be approximately one-fourth inch wide and may be much wider. If the labial and buccal flanges are sealed in by the lips and cheeks no air can be admitted at these borders, if the entire maxillary surface has moisture contact there is practically no air within and if the palatal border is well adapted to and extends sufficiently upon yieldable tissue to form the required valve the conditions are perfect to produce the emergency vacuum. There is now no vacuum but molecular attraction;

but if force is applied in any manner, that is, downward, sideways or forward the plate will be drawn away (slightly) from a portion of the tensest tissue enclosed thereby producing a, relatively speaking, perfect vacuum (14.7 pounds per square inch) over the entire surface from which the plate is dislodged. This suction will exist so long as the force is applied or until air can gain access to the vacuum space.

Adhesion by Contact.—This retentive force is often confused with atmospheric pressure, whereas it is an entirely different principle. Atmospheric pressure retention is contingent upon a chamber which is more or less evacuated of air, while adhesion by contact is conditioned by uniform pressure and absolute contact. To comprehend this principle of retention, the molecular forces of attraction and repulsion must be appreciated. These two molecular forces, to a greater or less extent, exist within and between all bodies. In solid matter attraction predominates over repulsion, whereas in liquids the two forces are equal, and in gaseous matter repulsion predominates over attraction. Attraction is always stronger between like atoms than between unlike atoms. (This last fact is beautifully illustrated in the low-fusing alloys composed of tin, lead, bismuth, and cadmium. These metals range in fusing-point from 442° F., to 617° F., yet when they are properly combined they may fuse at 135° F., thus demonstrating that the molecules of these metals create a marked repulsion for each other, and that it takes but a low degree of heat to render attraction and repulsion equal, that is, for the metals to fuse to a liquid state.) When like atoms are brought into atomic relation to each other, they are said to be held together by cohesion; when the interatomic space is exceeded, they can only be held together by adhesion, either by mass attraction or an intervening adhesive substance. Thus, it is apparent that the expression "uniform pressure" and "absolute contact" are misnomers, because absolute contact is an impossibility; but when these terms are used, they signify the closest mechanical contact of the mass, and do not refer to the atom relationships. When masses of matter are brought into mechanical contact and are caused to adhere by a film of

non-adhesive fluid, it might be thought that the adhesion is due to the strength of the fluid; but this is not the case because the thinner the film the greater the adhesion. That this adhesion is not due to atmospheric pressure may be demonstrated by suspending two masses of matter adhering by contact in the chamber of an air-pump and exhausting the air, when the adhesion will remain the same or stronger than under normal atmospheric conditions. Therefore, through an understanding of these axioms regarding attraction and repulsion, we can appreicate how artificial dentures are retained by the so-called adhesion by contact.

Leverage.—In mechanics the lever is a rigid bar working upon a pivot. The pivot is called the fulcrum, and the bar is considered as two portions called arms, the one called the power arm and the other the work arm. There are three groups of these factors—fulcrum, power and arms—called classes. In the first class the fulcrum is between the power and the work, whereas in the second class the work is between the fulcrum and the power; in the third class the power is between the fulcrum and the work. In the retention of artificial dentures the lever of the first class only need be considered and it is of great importance. This principle, of physics is involved in every case of prosthetic restoration, either in its positive or negative sense, and too often in both. In complete artificial dentures the alveolar ridge constitutes the fulcrum, and the retention of the base-plate, by either atmospheric pressure or adhesion by contact, constitutes the power; the portion of the base-plate upon which these retentive forces exert their influence constitutes the power arm. The teeth form the work arm, and antagonization is the work. In partial artificial dentures the remaining natural teeth and roots may be the fulcrum or even fulcrums.

The law governing the direction of energy should be taken into consideration. The law is: Energy moves in a straight line and at right angles to the surface from which the force emanates. Thus, in the line of energy there may be great resistance, while laterally there would be but slight resistance. (This is well illustrated by two moist plates of glass held together by adhesion by contact, which will offer much

resistance to an effort to pull them directly apart, but only slight resistance to lateral pressure.)

The anatomical relation of the mandible to the maxilla is a peculiar one, and offers many problems in physics. As resorption of the alveoli progresses, these adverse conditions become exaggerated. Therefore it follows that artificial substitutes should be inserted soon, that is, within a few weeks—two to six—after the removal of the natural teeth. As the resorption of the alveolar processes progresses, the summit of the alveolar ridge of the upper jaw recedes upward and inward, whereas the summit of the alveolar ridge of the mandible recedes downward and outward. Hence, if the artificial teeth are set in the position occupied by the natural teeth, the problems in leverage become very serious. It is apparent that if the upper teeth could be arranged with their buccal surfaces just inside the summit of the alveolar ridge, it would be impossible to dislodge the base-plate by direct occlusion, no matter how hard or circumscribed the bolus of food; but it is not practical to so arrange the teeth; it is desirable, from a mechanical point of view, to approach this condition as nearly as the individual case will permit. If after the alveoli have thoroughly receded the upper artificial teeth are mounted upon the base-plate in their normal distance from the raphé, the work arm of the lever is relatively much lengthened. Therefore, to overcome this untoward leverage the teeth are drawn in toward the summit of the ridge. There is a limit to the inward drawing of the lingual surface of the teeth, for undue encroaching upon the domain of the tongue will ensue. That this work arm may be still further shortened, the artificial teeth buccolingually are made narrower than normal. As the shortening of a radius shortens the circumference of a circle, it becomes necessary to select artificial bicuspids and molars a little narrower mesiodistally than the natural teeth which they replace. This is but one of the reasons for the reduced size of the grinding teeth. The other reason for reducing the size of these teeth has to do with their power, and should not be discussed together with the principles of retention. It has already been stated that motion—

force—moves at right angles to the surface from which the motion emanates, therefore the shaping of the facets of the occlusal surface of the bicuspids and molars is an important factor in the problem of leverage.

CONDITIONS AFFECTING RETENTION OF FULL ARTIFICIAL DENTURES.

There are four factors to be considered in the retention of base-plates: Size, that is, the amount of surface covered; soft tissues; fluids of the mouth; and the shape of the portion covered.

Fig. 165

Size.—In any given case the amount of retention by adhesion by contact is, like atmospheric pressure, according to the area of the surface (Fig. 165). Hence, other things being equal, the larger the denture the better the retention.

Soft Tissue.—No one factor has so much to do with retention of artificial dentures as the soft tissues. These may be divided into three classes—muscles and their attach-

ments, submucous tissue, and the mucous membrane. As an axiom, it may be stated that a base-plate cannot rest upon a muscle which impinges upon or draws over the periphery of the plate, as the contractile power of the muscle is greater than the retentive force of adhesion by contact; but not of atmospheric pressure. The muscle attachments should always be observed in examining the mouth prior to taking the impression; then, in taking the impression, the muscles should be marked in the impression, so that the base-plate may secure a close adaptation about the muscle attachments, and yet not cause irritation thereby. As adhesion by contact is in the ratio to the surface covered, it is apparent that the base-plate should extend as far in every direction as the attachment of the muscles will permit, but not so far that the muscles when placed upon their greatest tension will impinge too heavily upon the periphery of the base-plate. This may give a very irregular outline, but the proper outlining of the periphery of the base-plate is one of the important operations in adapting artificial dentures. Beginning in the median line, the labial flange of the upper base-plate should be well cut away for the labial frenum, then gradually ascend to the cuspid eminence, where for cosmetic effects it must be as high as possible. After forming the outline of the cuspid eminence, the border of the flange abruptly drops to accommodate the buccal frenum. The remainder of the border to the tuberosity must be kept as high as the attachment of the buccinator muscle will permit. In passing around the tuberosity, or its remains, there should be no sharp edge presenting, but a comparatively broad flat one, approximately one-fourth inch, to rest upon the soft tissues. After trimming the base-plate to what seems to be the proper outline, it should be tested by moistening the maxillary surface, placing it in the mouth, and instructing the patient to exhaust the air from between the base-plate and the soft tissues, upon which it rests, by firm pressure. The patient should then be requested to vigorously work the muscles of the lip and cheeks, and see if in any way the base-plate may be dislodged. If so, the patient should again attach the base-plate, the operator grasping the lip and cheeks, one portion at

a time, between the thumb and finger, and firmly extend the tissues outward and downward to detect any excessive muscle bearing, which should be relieved. The base-plate (of vulcanite or metal) is removed from the mouth, dried, and modelling compound penciled on the whole length of the palatal border, post-dammed, and, *extended backward* until the desired retention is secured. If it is demonstrated that a palatal addition is required it must be incorporated in the finished denture, by some feasible method.

The lower base-plate is of the horseshoe or crescent shape, and necessarily covers much less surface than the upper one; but if the impression is properly taken and the periphery properly adjusted for the muscle attachments, the base-plate can be seated, and sometimes considerable adhesion obtained. Some writers would lead one to believe that all lower artificial dentures should have a deep lingual flange, while other writers would have the lingual flange almost entirely removed. Both are partly correct, because some cases require the one treatment and other cases the other method. In those cases in which the crest of the alveolar process of the mandible is pronounced, and the attachment of the mylohyoid muscle is low upon the lingual wall, the lingual flange of the base-plate can and should be carried well down, for retention is according to the area of the surface, and the larger the base-plate the greater the resistance to the force of mastication; but if there is excessive resorption of the process, and the attachment of the mylohyoid is at or very near the crest of the slight ridge remaining, or if there is a sharp edge representing the union of the lingual plate of the mandible and the remains of the alveolar process, there should be almost no lingual flange to the base-plate. If in taking the impression the mylohyoid is compressed and depressed, the apparent space for a lingual flange will prove very delusive and troublesome: also, if the base-plate is carried over the sharp lingual edge often found upon the mandible, much irritation will be produced. In these cases the only means of success is to cut away the lingual flange, if one has been formed. In constructing the superstructure upon this properly fitted, short, lin-

gual-flanged base-plate, an extra retention flange of one-sixteenth to three-sixteenths of an inch in width may be extended horizontally into the mouth, when the glands and folds of mucous membranes resting upon this enlarged base-plate will often be of much aid in retention. The buccal flange should be kept as broad as the muscle attachments will permit. The same tests applied to the upper base-plates should be used with the lower.

Submucous Tissue.—In this class is included all the soft tissue of whatever histological formation—except the muscle tissue just considered—lying beneath the mucous membrane upon which the base-plate rests. When a moderate amount of soft tissue is evenly disposed beneath the mucous membrane, the very best condition possible so far as this tissue is concerned is presented. In some mouths the raphé of the maxilla will be found overdeveloped and covered with a thin, tensely drawn mucous membrane, while upon either side there may be an area extending well toward the base of the alveolar process with more or less submucous tissue, and a portion of the alveolar ridge composed of soft, flabby tissue only. If an aged patient presenting such a mouth has not long since acquired the knack of wearing artificial dentures, the chances of his success are very unfavorable. The treatment for such a case would be to relieve the pressure upon the whole length of the raphé, let the soft tissue in the vault alone, and increase the pressure upon the soft portion of the alveolar ridge. A vacuum chamber in such a case, placed over a portion of the tense membrane in the highest portion of the vault, would be a source of irritation and useless.

Mucous Membrane.—This membrane must bear the burden of supporting all complete artificial dentures, therefore an appreciation of its capabilities is an important factor to the prosthetist. In examining the mouth prior to taking the impression the condition of health of this tissue over which the base-plate is to be placed should be noted, and if necessary, the required attention given. There are two qualities of this membrane to be considered, tone and tension.

Tone.—The mucous membrane is much influenced by the health of the individual, and may be quite an index of the condition of the general system. The patient will learn that when the general system is vigorous and rested, the denture will have its maximum retention, but when the system is debilitated or relaxed from temporary exhaustion—tired—the retention of the denture will be poor and troublesome. When patients complain that their dentures are not "sticking up" as well as they did, it is well to investige the tone of the system and explain this principle. When the mucous membrane loses tone for any reason, the retention of the denture will be correspondingly affected. When dissolution is about to take place, it may be noticed that artificial dentures cannot be retained at all. Because of this quality of tone other conditions being equal, the younger the patient the better the retention. Aged patients in a debilitated state of health and unacquainted with the use of artificial dentures should not be encouraged in having their mouths fitted to new dentures, for the tax upon their vitality may be too great, and hasten their death.

Tension.—When a surface upon which a denture is to be worn is covered with a healthy mucous membrane, evenly underlaid with a medium amount of submucous tissue, and the tone is good, so far as the tissues are concerned, the very best conditions exist for retaining an artificial denture.

When the soft tissues covering the roof of the mouth are thin and tense, the case is much more difficult. In the former case the tissues will quickly conform to the hard base-plate, and if there has been a reasonably skilful construction of the appliance, the retention will be satisfactory. In the latter case, with the most skilful construction, it will often require an hour or two before the mucous membrane conforms to the unyielding material of the base-plate. It is this class of cases that tempt the dentist to use velum vulcanite lining at the periphery of the base-plate, or to resort to the patent soft vulcanite retainers. As this condition of the mouth is the only logical one in which these retainers are permissible, little harm is done if they are never used where not indicated. In these cases of tense mucous tissue no sharp edges or

localized increased pressure by any means whatever can be tolerated. Carving of the cast is contra-indicated.

There are rare—very rare—cases in which the mucous membrane is extensively underlaid with soft tissue over the roof of the mouth, and deeply fissured. Such cases may justly be classed as unfavorable for retention. The cast of such a case may be carved with impunity. The object sought in carving is to cause the periphery of the plate to imbed itself more firmly, or to raise a bead just inside of the periphery. This temporarily creates a large vacuum chamber, but as soon as the raised portion becomes imbedded in the soft tissues, adhesion by contact is secured. In some cases the bead acts as a barrier to the ingress of an excessive amount of fluid. The treatment mentioned in this paragraph is so rarely indicated that the writer expects never to use it again; but takes this means of expressing his disapproval of the common use made of it.

Many cases presenting will have areas of thin, tense tissue, and other areas of excessively soft tissue. The treatment for this class of cases has already been stated, that is, relieving of the pressure upon the tense tissue in the proximity of the raphé, to the extent of its entire length. This can usually be accomplished by the addition of one or two layers of No. 60 tinfoil. The soft areas over any portion of the vault should not be changed, but an excessively soft tissue upon the alveolar ridge should have a firm peripheral bearing extruding beyond it. Rarely should any hard portion of the alveolar ridge be relieved, and then only when very circumscribed.

Fluids of the Mouth.—The normal thin watery fluid of the mouth is most favorable for retention by adhesion by contact. The fluid makes the contact, but does not hold the base-plate so far away as to interfere with the adhesion by contact. When the fluids are vitiated, thick, and ropy, they may have sticky properties, but not enough to compensate for the interference with adhesion by contact. Temporarily these vitiated secretions can be removed from the mouth by thoroughly washing with an alkaline solution, then inserting the denture well moistened with cold water.

Shape.—The shape of the surface upon which an artificial denture is to rest has much to do with its retention. Side walls are useful to prevent lateral motion; but a flat surface in the vault, or floor of the mouth, is essential for the best retention. No matter whether the vault is high or low, or the alveolar process of the mandible is high or low, the retentive surface is the horizontal area covered. A high, inverted, V-shaped vault or prominent alveolar process of the mandible is especially unfavorable for suction.

PRACTICAL APPLICATION OF THE PRINCIPLES OF RETENTION.

The retention of full dentures may be said to be by four forces: two passive—first, base-plate outline, and second, resistance to force (leverage)—and two active—first, molecular (adhesion by contact), and second, atmospheric pressure.

Base-plate Outline.—Much of the burden of the discussion in Chapter I is developing the anatomy of the mouth as a support for and retention of artificial dentures; therefore the chapter may again be read with this subject, "base-plate outline and retention," uppermost in mind. Figs. 65 and 66 illustrate outlines for a specific upper and lower case. If the impressions are properly taken the landmarks are defined.

Leverage.—Figs. 166 and 167 illustrate the application of force through the teeth upon the base-plate. Where there are two facets, as in the bicuspids, the force may be applied from either facet, then the direction of the force will be at right angle to that surface; but if the force is applied to both surfaces, the direction of the force will be the resultant, and parallel with the long axis of the tooth or teeth. Each specific case should be carefully studied, and these two factors, outline and leverage, should be so controlled that they aid in retention and not in dislodging the artificial dentures. These factors are classed as passive forces, because it is through them that active muscular force may cause destructive motion. Fig. 168 illustrates a practical case

in which success was not attained until the tilted molar on each side of the mandible was cut down and crowned.

Fig. 166

Fig. 167

Molecular Attraction, or Adhesion by Contact.—Adhesion by contact is described by the catchy phrase, "uniform pressure and absolute contact," while in fact, neither statement is true. What is meant is, that the base-plate is so adjusted that it

Fig. 168

resists force applied at any point within the base plane. In practice this means that the heaviest bearing of the base-

plate is at and near the periphery. Absolute contact means that there are no cavities made in the surface of the denture as suction chambers; but it does admit of and requires relief of inclosed hard places. These relief spaces undoubtedly do cause temporary suction, but this is incidental and not the object. The shape of these relief spaces are usually different from that of vacuum chambers. They conform to the shape of the hard portion to be relieved, while the vacuum chamber is in miniature the outline of the alveolar process. The most commonly required relief is along the

FIG. 169

raphé of the maxilla (Fig. 169). This relief may be made by adding one or more thicknesses of number 60 S. S. W. tinfoil. This foil is $4\frac{1}{2}$ thousandths of an inch thick, hence the desired depth of the relief space may be obtained by additional layers of foil. The relief should be over the whole length of the hard portion, even though it extend from the crest of the alveolus to (and even through) the palatal border of the base-plate. However, the palatal border should be, if possible, one-fourth inch distal of the relief space. Fig. 170 represents three layers of relief tin. The first, the smallest

one, is fastened to the plaster cast with sandarac varnish, the second one in size is glued over the first, and the third and largest is fastened in like manner. Any circumscribed hardness, as nodules, wherever located, should be relieved in the same manner as described for the raphé. Another method for relieving the hard places is by compressing the soft places. This should be done by the manner in which the impression is taken which is discussed in Chapter II. In few cases is it advisable to carve the impression or cast to produce this relief, as the amount removed cannot be correctly gauged, nor the original condition restored if desirable.

Fig. 170

Atmospheric Pressure.—Since its application to artificial dentures, in 1840, there has been and is much confusion of thought and expression over the theory and practice with this physical force. The student, after giving consideration to the truths stated in the preceding sections of this chapter, should have no difficulty in formulating a terse statement, for memory purposes, as: Molecular attraction, mass attraction, or adhesion by contact (used as synonymous terms) implies a mechanical contact; and atmospheric pressure implies a space with some degree of emptiness.

It is evident that the most advantageous position for a vacuum chamber is about the gravity center of the denture which has the least motion, and where the leverage is equal in every direction; provided a vacuum chamber is to be used. An air chamber in an artificial denture is always injurious to the tissues and often a positive obstruction to the best retention.

Vacuum Chamber Indicated.—It may justly be said that a vacuum chamber is never indicated; but that its use is an evidence that the dentist has not confidence in his ability to discard it.

If a chamber is determined upon the following instruction may be useful:

Edges.—The edges of relief spaces should be almost imperceptible, while the edges of a vacuum space should be at right angle to the contact surface. The depth of the vacuum cavity should vary from $\frac{1}{64}$ to $\frac{1}{16}$ of an inch. The thinner and tenser the tissue the shallower the chamber, and *vice versa.*

Material.—Block tin or tin alloyed with lead is used to form the vacuum chamber. Pure lead may be used, but it imparts a dark discoloration to the vulcanite. The pattern metal found at the supply houses is tin with a small amount of lead. The material should be purchased in sheet form and cut for each case. As the metal is supplied in sheet form $\frac{1}{16}$ of an inch thick, a small portion should be rolled to $\frac{1}{32}$ of an inch and the larger portion to $\frac{1}{64}$ of an inch in thickness. All fanciful forms having sharp angles (as heart- or shield-shape) should be avoided because they are an unnecessary source of irritation.

Attaching.—There are various ways of attaching the chamber forms to the cast, as a thin mix of oxyphosphate of zinc cement (best), sandarac varnish, very small tacks, or a short portion of pins. Fig. 171 shows a cast with a vacuum chamber form attached with pins. When the cast is to be coated with tinfoil the varnish and foil will suffice to hold the chamber form.

For Castings.—The methods described for forming relief spaces and vacuum chambers are suitable for all methods of

base-plate formation excepting those by the casting method; for which, owing to the high heat required, these methods cannot be employed. For the casting method the relief spaces and vacuum chamber may be provided for by carving from the impression, or, better, by adding to the surface of the cast a fine-grain investment compound. This addition is made by tracing, with a pointed instrument or sharp-pointed lead-pencil, the outline of the desired addition, thoroughly saturating the surface to be added to with water, and painting on the material as a thin mix. A mixture of two parts, by measure, of wash silica, one part plaster of Paris, and water to make a thin cream is excellent. When the added material is nearly hard set it is carved and burnished into form.

Fig. 171

Other Forms of Vacuum Chambers.—The vacuum chamber thus far considered and commonly used is known as the unilateral chamber; that is, it is one and extends equally on both sides of the median line. There are cases in which this form of chamber is not applicable, as cleft-palate, deep-fissured palate, an inverted V palate, also an overdeveloped raphé. Fig. 172 illustrates an overdeveloped raphé. In such cases a bilateral chamber is indicated if any is to be used. A bilateral chamber consists of a complete chamber

upon each side of the median line. Fig. 173 is an illustration of a case requiring such treatment.

FIG. 172

FIG. 173

Soft Vulcanite.—The use of "velum rubber" (soft vulcanite) retainers is a questionable method. It is certainly unsanitary and rarely justifiable. There are two general plans for using velum rubber: (1) As a peripheral border

of the vacuum chamber, or the outer edge of the plate. (2) In the form of disks, either as a large central disk or as small disks distributed about the surface. The rationale of the first method is to provide a flexible rim that may be readily adapted to a thin, tense, mucous membrane. In such cases the method has the stamp of being scientific, but it is unscientific and has the stamp of ignorance to use the method when the tissues are excessively soft and stability is the result desired. The second method consists of attaching soft vulcanite disks to depressions in the maxillary or mandibular surface of the denture (Fig. 174). The rationale

Fig. 174

of this method is that the thin pliable disk, by the aid of moisture, easily conforms to a surface covered with thin and tense mucous tissue; then as traction is applied to the denture it draws the center of the disk away from the tissue, thus forming a vacuum. It is obvious that such a denture is pendently seated, but that it will require much force to remove it from the mouth. The mouths where such methods are indicated are rare, and to insert such unsanitary appliances when other methods, properly used, would meet the requirements is reprehensible. As velum rubber contains but two-fifths as much sulphur as hard vulcanizable rubber it is evident that the soft vulcanite is but two-fifths "cured;"

therefore it is easily understood why the material is so much less durable, swells, changes form, acquires an offensive odor, and requires renewal every few months. "Velum rubber" should never be used in the mouth except where the conditions cannot be met by other means, and then it should be renewed often.

There are conditions of the lower jaw that can be met with vellum rubber better than with any other material; however, even in these extreme cases the material should be used only as a last resort, and then after the patients have had explained to them the nature of the material and the continued expense.

Conditions of the mandible indicating velum rubber are excessive resorption with nodules and sharp ridges upon the surface of the bone, and soft tissues very thin and sensitive, especially to a sliding movement.

The technic for constructing a hard vulcanite denture with a velum vulcanite lining is peculiar to the material, but easily comprehended.

The Spence compound cast and wax occlusion model having been obtained, are mounted upon a New Century Antagonizor. The wax-occlusion model is now laid away for future use. The surface of the mandibular cast should be freed of all wax and the surface rubbed with talcum powder. A piece of thin tinfoil is smoothly and perfectly adapted to this powdered surface, upon which the denture is to rest, one thickness of pink base-plate wax, and over this a layer of heavy (No. 60) tinfoil are conformed. This represents the portion to be replaced with velum rubber, and is called the base-plate; upon this foundation of tin and paraffin, or base-plate, a small roll of soft yellow wax is placed, in which a soft-iron wire is imbedded for rigidity. Upon this roll of wax the teeth are mounted and occluded. This built-up trial denture is tried in the mouth and if satisfactory is returned to the antagonizor; the yellow-wax rim mounted with the teeth is thoroughly chilled and carefully removed from the base-plate. This teeth-mounted wax rim not being distorted, is flasked, packed with hard vulcanizable rubber, and vulcanized. The hard vulcanite rim is

thoroughly polished, except the base surface, which is scraped and the edges filed to a slight bevel looking outward. This vulcanite rim is now returned to the antagonizor, occluded, and waxed to the paraffin tin base-plate. The entire labiobuccal and lingual surfaces are nicely covered with heavy tinfoil, even extending upon the porcelain teeth. (Remember the original cast is upon the antagonizor and is to remain there.) The tin-covered denture is now flasked with French's Regular Dental Plaster so that the separation is exactly at the periphery of the base-plate. The flask is opened and the base-plate removed. The cast upon which the velum rubber is to be vulcanized is now in the lower section of the flask and was formed from the mandibular surface of the tinned base-plate. If the tin was carefully formed upon the Spence compound cast and the first half of the flasking carefully done the new cast will be a perfect reproduction of the original. This is to be covered with thin tinfoil and soaped. The next step is a very important one. The exposed surface of vulcanite must be thoroughly cleaned of wax and dirt; flush away the wax with hot water, wipe dry, and rub well with a cloth saturated with chloroform. This surface is then covered with a hard vulcanizable rubber cement (bow-spring rubber dissolved in chloroform to the consistency of thick cream). The cement is evenly painted over the surface of vulcanite, and when the chloroform has nearly evaporated sufficient velum rubber (preferably black) is packed upon it to fill the mold. Vulcanize the same as hard rubber. When the case is taken from the flask and the tinfoil removed it is finished except the peripheral edges of the velum rubber. These edges are trimmed away with sharp scissors, seared with a hot iron, and the burned soft vulcanite removed with chloroform. In a few moments the chloroform will have evaporated and the case is finished; however, it is well to again gloss the hard vulcanite with a soft brush wheel and chalk.

The antagonizor bows mounted with the original casts and wax-occlusion model arc filed away for future use.

When it becomes necessary to renew the velum rubber the bows mounted with the casts and occlusion model are

returned to the antagonizor, the velum rubber is cut away until a surface of hard vulcanite is obtained, a new tin and paraffin base-plate is formed, and the teeth upon the hard rim of rubber are occluded and attached to the base-plate. The remainder of the process is the same as constructing the original velum lining.

As all the strength of this denture is in the hard vulcanite it is well to use a reinforcement. This is done by inserting a No. 12- to 16-guage wire of clasp gold or iridioplatinum. This is done when packing the hard vulcanite rubber. With the pins of the teeth imbedded in red rubber and the pink rubber facing in place, the wire stiffener, previously conformed, is placed at the cervix of the teeth and the packing completed.

The technic for applying the tinfoil is described in Chapter IX.

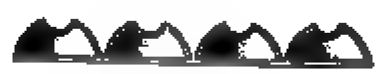

Fig. 175 Fig. 176

Speyer's Cohesion-surface Forms.—Speyer's "cohesion-surface forms" (cohesion improperly used) is heavy tinfoil, the surface of which is covered with minute papilliform prominences. The claim of strong adhesion due to the peculiar conformation is hardly tenable; however, they are decorative and are satisfying to the mind of some patients; nevertheless, the same thickness of plain tinfoil would produce the same physical results. Fig. 175 shows the material as it is procurable at the supply houses. It should be used only

upon the surface requiring relief. A half-sheet properly shaped is usually enough for one denture. Fig. 176 is a section of the "cohesion-surface forms" enlarged four times to better show its construction. These "cohesion-surface forms" were used in several of the dentures illustrated in this book. "Contraptions" for retaining artificial dentures, as sometimes seen in supply houses, are not only injurious to the mouth, but often a detriment to retention. The denture is often strongly retained in spite of the appliance. The student should be able, with his knowledge of anatomy and the laws of physics, to detect the unscientific things.

Conclusions.—Having made a somewhat extensive study of the principles of retention for full dentures, and their practical application, it is *a propos* to make a critical analysis of the present-day technic methods. It is evident that:

1. A centrally located vacuum chamber is very limited in retention power and permanence; also, it is injurious to the tissues.

2. An areal contact denture, properly extended, has the greatest retention power, is durable and not injurious to the soft tissues.

3. The principles of retention, also of cosmetics, must be considered in taking impressions.

4. Modelling compound impressions are apt to and usually do form spaces in which there is not contact, therefore is deceptive and unreliable.

5. Plaster necessarily forms a real contact, therefore is the reliable and positive material for impressions.

6. There is much misunderstanding of the anatomy and physics involved in impression taking.

7. The purpose of an artificial denture is for efficiency in mastication, and cosmetics or restoration of the features. Therefore, an impression method that is intent upon the one and ignores the other is inefficient. The modern modelling compound method is designed for great retention power; but the material is deceptive in that it produces, in ordinary hands, temporary atmospheric spaces. The modern plaster impression method is the basis for creating the greatest possible retention, and also for restoring the features.

8. The professional man should not be satisfied with suction that is based upon empirics; but he should be intent upon producing the best results. This latter category is the attribute of mentality, therefore professional and not empirical.

"MUSCLE TRIMMING" AND "CLOSED MOUTH" METHODS. —On page 125 these methods were referred to as erroneous, that is, based upon mistaken ideas of anatomy and physics. Such a statement needs substantiation; without which it is unjust to the authors of the methods.

"Muscle trimming" is designed to accomplish two objects: (*a*) preventing the labial and buccal muscles dislodging the plate, and (*b*) preventing irritation of the soft tissue at the border of the base-plate. The former is erroneous, but the latter is in part true.

In this discussion it is assumed that modern methods for impression taking, both plaster and modelling compound, as relating to retention of artificial dentures only are under consideration.

The buccinator and muscles inserted into the lips are the ones involved. Whatever is true of the buccinator dislodging the denture is also true of the other muscles. So far as this study is affected the origin and insertion of the buccinator is at the union of the alveolar processes and the body of the maxilla and mandible. The buccinator is not a muscle of much power but sufficient for its normal function, that is, keeping the bolus of food between the teeth. When the mouth is closed it has no appreciable power unless the cheeks are distended with food or air. While the mouth is wide open the origin and insertion are far enough apart so that the contractile action of the muscle may exert some power. This force cannot dislodge the upper denture for if it displaces the denture any appreciable distance (even one-ten-thousandth part of an inch) and there is suitable adaptation and extension of the palatal border of the base-plate a perfect vacuum is created and atmospheric pressure (of approximately fourteen pounds to the square inch) is produced upon the entire surface affected. This is true also of the lower denture provided the necessary conditions are

present to create a vacuum. There is power enough in any or all of the muscles under consideration to reduce the flanges of the soft impression material to the extent of *destroying all possibility of esthetic restorations*. However, the "muscle trimming" depresses the peripheral border so much that there is little probability of irritation from the pressure of the border of the base-plate.

The "closed mouth" method is still more destructive of esthetic restoration than the open mouth method, because the orbicularis oris including its bony attachments (the angle and frenal muscles) is more actively brought into action. The misconception of the dislodging action of the muscles upon the denture is just as true with this method as with the former. However, this method has demonstrated the action of the masseter upon artificial dentures. It demonstrates this action by its shearing effect upon the distobuccal angle of the upper and especially the lower modelling compound impression. This action of the masseter is only marked in a large development of the muscle. The student may study the action of this muscle by placing the index finger in the mouth with the thumb externally grasping the muscle, occluding the teeth, and contracting and relaxing the muscle. This muscle action cannot dislodge the denture because the stronger the muscle acts the stronger the dentures are clamped in place. However, it may cause much irritation and necessitate the trimming of the base-plate at the location indicated. One should hardly need to use the closed mouth method for impressions, with its attendant evils, for the purpose of recording the action of the anterior border of the masseter muscle. Nevertheless the action of this muscle when obstructive must be accommodated.

This condemnation of the "muscle trimming" method, as a rule of practise, necessitates a superior method. No catchy expression can be substituted for "muscle trimming" for establishing the peripheral border of the impression (and denture), for a scientific method must be based upon an appreciation of the anatomy and physiology (physics) of the parts involved. Nevertheless, the classification of requirements for retention, namely: (1) Areal contact, (2)

peripheral bearing, and (3) extension for retention, should be constantly in mind when determining the location of the peripheral border of the impression and base-plate.

There are two extreme conditions of the alveolar process that must be considered in determining the periphery. The one is the full prominent process and the other is the excessively resorbed process. (These conditions are diagrammed in Fig. 16.) Necessarily all cases presenting are somewhere within the extremes and must be a modification of the extreme governing the specific case. As the one object of the impression is construction of the denture, the peripheral border of the impression can best be determined by considering the requirements for the flanges of the denture. In the first extreme condition (prominent process) the flanges of the denture should be as thin as possible and necessarily the extent is only to exclude air. In this extreme condition the base-plane, and consequently, the peripheral bearing, is at the crest of the alveolar process (Fig. 16). In the other extreme condition (excessively resorbed process) the flanges are most important because they provide the peripheral bearing and restore the contour. Thus, it is evident there is value and necessity for the peripheral wax additions for plaster impressions as elaborated in the chapter on Impressions. In this class of cases the bearing must be as near the muscle attachments as possible. Also the flange may extend a short distance upon the muscle to act as a valve.

Is the mental vision clear? Areal contact over the entire base-plane, peripheral bearing and extension for retention, with emphasis upon palatal extension.

NOTICE. — The emphasis that has been placed upon extension for retention is apt to impress the novice that all full cases require this excessive extension; that is not true. The large majority of the cases presenting to the general practitioner are average in size, form, quantity and tone of soft tissues, and quantity and viscosity of the fluids of the mouth. Such cases are well retained with much less surface of the mouth covered; nevertheless, the larger the area of the base-plane, other factors—pro and con—being duly considered, the greater the retention.

Irritation from Extension.—Naturally a broad, flat surface cannot cut, that is irritate, as will a knife edge; therefore emphasis has been placed upon having the palatal extension one-fourth inch wide, and that the soft tissues covered with this extension must be held firmly against its bone support throughout its entire length. This compressive action should be produced by the peripheral wax addition to the tray. Carving of the cast, in the estimation of the writer, is the most unsatisfactory and reprehensible method ever invented for creating retention in artificial dentures. If a scientific impression has been taken, the results of carving cannot be tolerated. The peripheral edge of the maxillary surface should be slightly rounded —never left angular. If irritation ensues, even after the most scrupulous and painstaking methods and technic, the student and young practitioner should not be discouraged. Nor should he place too much credence upon the overenthusiastic statements of some modelling compound hobbyists, in that the peripheral border of a denture made from a well-taken modelling compound impression should never be trimmed, but that attention should be given to some fault in the "articulation" of the teeth. "Whoever expects a perfect piece to see, expects that which never was, is, nor can be." When the human mouth can be worked upon as positively as a block of wood, then dentistry will be taken from the category of the professions and will be only a skilful trade. These last remarks are designed to caution the sincere and troubled ones against discouragement which is often engendered by the careless and extravagant expressions of some members of the profession.

Nausea.—Nausea is sometimes associated with impression taking and inserting of artificial dentures. Nausea is a result of the action of the mind, therefore its treatment is through the mind-suggestion. The operator should remember that a light tickling touch of the finger, impression or denture upon the palate is much more suggestive than a firm pressure. Many dentures have been ruined by cutting off the palatal border. Attention should be given rather to creating pressure of the border and often in extending it

backward. Tactful handling of the patient will overcome the worst cases.

Figs. 177 and 178 show two views of the peripheral border and palatal extension of a more than ordinarily difficult case.

Fig. 177

In this case it was essential that great retention and perfect enunciation should be obtained. The wax reënforced plaster impression, Spence plaster compound cast, vulcanite base-plate and double vulcanization were used. When the vulcanite base-plate was tried in the mouth it was found

Fig. 178

that with several repeated efforts the base-plate could be loosened. This fault was corrected by penciling on modelling compound to extend the palatal border and post-damming until it was impossible for the patient to loosen it by any

muscle action whatever. The compound was replaced with vulcanite at the second vulcanization.

Fig. 179 shows casts made by filling finished denture for cases that were desirous of better retention than formerly possessed. The line indicates the extent of the former denture.

Fig. 179

The author advises the reader to return to page 87 and reread the description of the technic for full upper and lower impressions. Begin with "Notice" and keep constantly in mind, while rereading the summary, areal contact, peripheral bearing, and extension for retention.

ROOFLESS PLATES.

The roofless plate may be defined as a saddle upper denture. Its base-plane is approximately two-thirds that of the usual base-plate.

The requirements for its successful application are a medium to large base-plane, prominent alveolar process and tuberosities, favorable condition of the soft tissues and fluids of the mouth.

Conditions contra-indicating a roofless denture: Small base-plane; alveolar process and tuberosities nearly extinct; soft tissues thin and tense; fluids of the mouth, ropy or deficient in quantity; and a personal equation antagonistic.

The roofless method is desirable for those patients that are very much annoyed by the usual palatal extension, those that complain of excessive heat, loss of taste and general discomfort from the distal extension. It is desirable in some

cases of excessively hard and enlarged raphæ, also excessively high V vault.

Principles of Retention.—Excessive peripheral bearing except over the zygomatic processes, with light or no contact over the crest of the alveolar process.

Material for Denture.—Vulcanite only.

Technic.—Plaster impression using compression wax where bearing is desired—plaster mixed thin; make vulcanite base-plate. Try the base-plate in the mouth and if the adaptation and retention are satisfactory complete as with the usual base-plate. If the adaptation is satisfactory but not sufficient retention, the peripheral bearing should be increased with stick modelling compound, having a shallow vent at the maxillary zygomatic processes thus providing an escape for the confined air. When satisfactory retention is obtained proceed as usual until the flask is opened when the vulcanite base-plate and its modelling compound addition are removed with the wax and the mold packed with the desired rubbers.

Durability of the retention of the roofless denture: Problematical. The strong retention obtained will be for a few months only, but if the mental attitude is compatible the strong retention will last long enough for the patient to acquire the artificial denture habit. Do not attempt this method with an adverse personal equation, nor promise the patient impossible results.

TENSOFRICTION.

This term is used to cover all those methods where retention is obtained by contact, but the surface of the contact is too insignificant to constitute a factor. It includes all forms of clasps, removable plate-bridge attachments, spiral springs, and spring plates. It implies that retention is obtained by friction through tension. The simplest form of tensofriction is the spring clasp, in which the narrow strip of metal grips the tooth by friction through the tension in the metal.

It is not relevant in this book to discuss that class of partial dentures known as "bridge-work;" only to say that

there is a large class of cases where the best interests of the patient will be subserved with a plate denture. In all cases the cosmetic effects of a plate are equal and in many places far superior to a bridge.

It is a good rule to consider that a natural tooth that is or can be made comfortable and useful to the patient is far more valuable than an artificial one. However, the conditions may be such that a remaining tooth or two in the upper maxillæ may be more of a detriment to the wearer of an artificial denture than their loss; but it is always a subject for serious thought.

In a few cases the partial denture may be retained by atmospheric pressure, adhesion by contact, or by the spring plate; but usually the best results are obtained by the use of clasps.

CLASPS.

There is an unjust prejudice in the minds of some dentists against the use of clasps. This is probably due to an improper knowledge of their advantages and disadvantages; also an insufficient knowledge of the mechanical principles involved and their practical application. The advantages of the clasps may be summed up in the statement that there is no method by which a partial plate denture may be retained with so much comfort and usefulness to the patient as with clasps. This implies that the conditions are favorable and the method is properly applied. The disadvantages are that in some cases the method should not be used because the remaining teeth are not healthful nor favorably located and may be of improper conformation. The last condition must preclude clasps. The principal argument used by those who object to the use of clasps is that they cause disintegration of the teeth to which they are attached. The writer emphatically states that the cases in which this is necessarily so are very few indeed; but that most of these unfortunate occurrences are due to imperfect knowledge and manipulation of the dentist. It is awe-inspiring to see how some of these men who throw up their hands in holy horror at the idea of clasping a tooth will, in a few minutes, "disinte-

grate" a sound tooth to the extent of removing the whole crown and pulp for the purpose of attaching a bridge. Some argue that a tooth should never be clapsed until it has been crowned. Why not wait until the necessity arises, and then fill or crown as may be necessary? "Consistency is a jewel." The question should be: How can a patient derive the greatest amount of service from a tooth? not, How can the tooth be preserved the greatest length of time? A tooth is of value only as it is of service.

Names.—There are various forms of clasps. A *stay clasp* is one that rests upon one side and perhaps two angles of a tooth, and is used as a bearing for a spring plate. A *spring clasp* is one that rests upon at least two sides and three angles of a tooth. *Rigid clasps* are clamping devices that telescope specially constructed artificial crowns. A *ferrule* is a continuous band about the tooth.

Stay Clasps.—The stay clasp is represented in vulcanite work by the thickened edge of the spring plate. The name is especially applied to the short clasps used to stay metal plates. This means may be used to support a spring-plate denture carrying any or all of the six anterior teeth, provided the bicuspids and molars are of proper form and alignment. The one essential factor for retaining a denture by the spring-plate method is that the distance across the vault from the bicuspids upon one side to the bicuspids upon the other side of the arch shall be greater at the gum margin than at some other portion of the crowns of the teeth. When the remaining teeth have the conformation and alignment implied in the preceding statement, a plate of a "horseshoe" shape, having perfectly adapted thickened edges of vulcanite (Fig. 180), or metal stay clasps (Fig. 181), may be sprung over the bulbous portion of the teeth. It will then rest in contact with the teeth, but without lateral pressure. It can only be removed by springing the heels of the plate inward. Should one or more of the retaining teeth be tilted lingually it will interfere with this method of retention. Perfect adaptation to the cervical third of the lingual surface is essential, and cannot be obtained, or at least retained, if there is an excessive inclining

of some of the teeth. There are cases where adaptation can be made to the middle third without contact with the

Fig. 180

Fig. 181

cervical third. This method is especially advisable where the conditions are favorable and there are no spaces for spring clasps, or the spring clasp would be unsightly.

Spring Clasp.—Probably the principal reason for the condemnation, by so many dentists, of the spring clasp is a lack of appreciation of the physical laws underlying their use and construction, and the manipulative ability to properly adjust them even after the principles involved are comprehended. Doubtless there is no place in dentistry where there is so varied an application of the physical laws of leverage as in the retention of artificial dentures; both full and partial cases.

Fig. 182

The Form of Tooth for Spring Clasp.—What is commonly called a bell-shaped tooth is the ideal form (Fig. 182). The greatest diameter of such teeth is from one-half to two-thirds the distance from the gum line, or gingiva, where there is recession of gum tissue, to the occlusal surface of the tooth. This being true, it follows that bicuspids and some of the molars only are suitable for clasps; and these must be of more or less pronounced nervous temperament type.

Choice of Teeth for Clasps.—Conditions permitting, the first choice for a tooth to clasp is the second bicuspid, the

second choice is the first molar, and the last choice is the first bicuspid. Any other placing of clasps is not ideal, and will be resorted to only because of necessity. Clasps may be placed upon third molars and cuspids, or one of each; but they will be so placed because there is no other alternative.

Fig. 183

The Portion of the Circumference of the Tooth Clasped.—The spring clasp should cover two sides and three angles of the tooth (Fig. 183), and be placed upon the distal and lingual surfaces of the bicuspids and the mesial and lingual surfaces of the molars. By this arrangement the clasps are placed at or near the center of leverage and as inconspicuously as possible.

The Longitudinal Portion of Tooth Clasped.—The pressure must be upon the incline toward the cervix (Fig. 184, *a*). Should the excess of pressure be upon the incline toward

the occlusal end of the tooth, the plate will be displaced (Fig. 184, *b*); therefore the clasp is placed over the middle third of the crown of the tooth. Often the tooth is not an ideal one, and is so formed that it becomes necessary, if a clasp is to be used, to carry it to, or even below, the free margin of the gum. These are the cases wherein there is danger of disintegration of the clasped tooth. Some teeth thus clasped, that are of a very dense nature and not prone to decay, may become very sensitive, which can usually be overcome by applying silver nitrate, 50 per cent. solution. Should the tooth belong to the class commonly called soft and chalky, and the secretion be in an abnormal condition, they may disintegrate very rapidly; the tooth should then

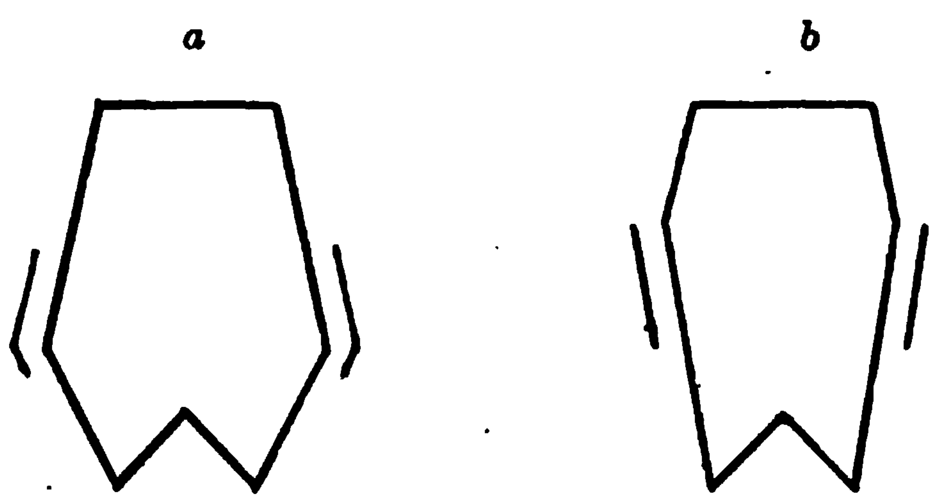

FIG. 184

be filled or crowned, as may be indicated. It is not often we have all these untoward conditions; therefore the method should not be condemned because of these exceptional cases. Where the teeth are of suitable length and form, even though the structure may be poor and the secretion vitiated, if the clasps are properly made, placed, and cleansed, there will be very little danger of decay. In all cases it is best to keep the clasps as far from the gum as the conditions will permit.

Forms and Material for Clasps.—Clasps are made of either round, flat, or half-round clasp gold. A good formula for clasp gold is: Pure gold, twenty parts; pure copper, two parts; pure silver and platinum, of each, one part.

Round Clasps.—The round clasp should be made of 17- to 20-gauge clasp gold wire, and may be used either as a single

or double strand (Fig. 185). There are several varieties of the round wire clasp that are very useful and admit of a wide range of application. These forms are often known by the

Fig. 185

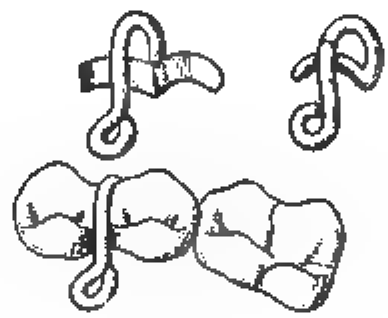

Fig. 186

Fig. 187

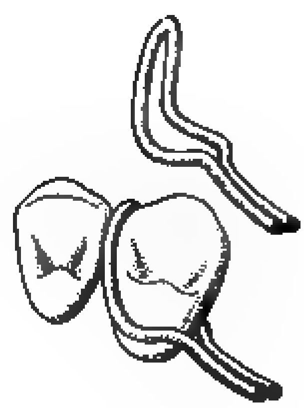

Fig. 188

Fig. 189

name of the man who introduced the special form to the attention of the profession. The Balkwill tee (Fig. 186, the Jackson-crib—a double tee—(Fig. 187) and the Roach loop (Fig. 188) are familiar and valuable forms. The advantage

claimed for the wire clasp is the slight contact with the tooth.

Flat Clasp.—The flat clasp is made of 26-gauge clasp gold, and from $\frac{1}{16}$ to $\frac{1}{4}$ inch in width, usually about $\frac{1}{8}$ to $\frac{1}{16}$ inch (Fig. 189). The advantages of the flat clasp are: (1) Its thinness—when necessary to pass between the natural teeth, the necessary space can be secured by slight wedging; (2) there is no form of clasp that is so universally applicable; (3) it gives great stability to the denture; and (4) it is not liable to be broken. The disadvantage is that the broad surface of tooth substance covered is favorable for decay, and necessitates the best judgment upon the part of the operator in placing the clasp, also care upon the part of the patient to keep it clean.

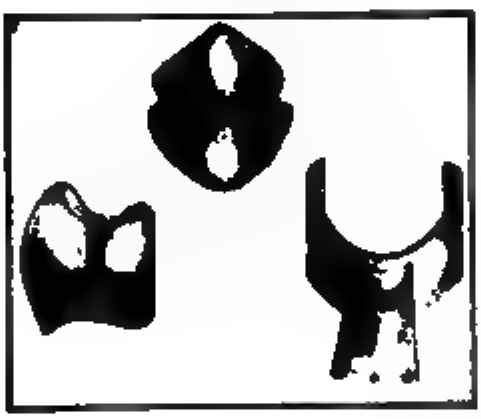

Fig. 190

Fig. 191

Half-round Clasps.—The half-round clasp is made of half-round clasp gold wire and has the disadvantages of both the round and flat clasps without their advantages. The half-round wire is valuable in forming lugs, stops and the stem to the tee clasp.

Rigid Clasps.—These clasps may be made of flat clasp metal or 18-carat gold plate; they are usually as broad as the length of the crown of the tooth will permit; they are of sufficient length to cover at least one side and two angles of the tooth, and the ends are either bent L-shape to slide over parallel longitudinal ridges or cleats upon gold crowns (Fig. 190) (Bryant method), or they are provided with a

thick end adapted to parallel longitudinal grooves in preferably porcelain crowns (Fig. 191) (Swartz method).

Ferrules.—Ferrules are especially indicated where the natural teeth are remaining upon one side of the maxilla or mandible and absent on the other. The ferrule is superior to the spring clasp for this class of cases because of its unyielding form (Fig. 192). Where conditions are favorable, two or possibly three may be used to advantage. Sometimes extensions may be attached to the buccal surface of the ferrule to act as stay clasps upon the proximating teeth. Should there not be sufficient space between the tooth to be ferruled and the proximating teeth to pass a 26-gauge plate, it will be necessary to gain such space by wedging with tape until such space is obtained, when it will be maintained by the ferrule.

Fig. 192

PRINCIPLES INVOLVED IN RETENTION.

There are two propositions to be considered: first, balancing the plate, and second, gripping the tooth or teeth.

Fig. 193

Balancing the Plate.—We may consider each side of a partial plate as a lever, the tooth clasped as the fulcrum, and the plate extending either way from the clasp as the

arms of the lever. Fig. 193 represents a partial upper of a horseshoe-shape carrying the six anterior teeth and the wings extending backward to the third molars. It is easily imagined what the result would be should an attempt be made to retain this denture by a single-strand wire clasp placed upon the third molars; also, should the wire clasps be replaced with broad, flat clasps accurately fitted to the surface of the teeth. With the broad clasps, the anterior portion of the plate would be held in place for a time at least, but the long leverage and the weight of the porcelain teeth would place such a strain upon the third molars that

Fig. 194

they would become very sore and loosened in their sockets. If these clasps are replaced with single-strand wire clasps upon the second bicuspids, the plate will be securely held in place and with the minimum strain upon the clasped teeth, because the clasps are at the center of leverage. This demonstrates why it is necessary to extend the base-plate some distance back of the clasped teeth. This center also explains why, if a clasp is placed upon a third molar upon one side, a clasp should be placed upon the first bicuspid, or even the cuspid, upon the other side of the arch. It is obvious that the best results are obtained when there is a tooth for clasping upon each side of the mouth. While two teeth for

clasping are most desirable, if the conditions for retaining a denture by adhesion by contact are very unfavorable, a single bicuspid or molar may be of much assistance (Fig. 194); and on the mandible even a single cuspid should be utilized.

Gripping the Tooth.—There are many cases of failure in clasp dentures due to carelessness or slight accidents in adjusting the clasps to the teeth. The clasps should be so adjusted to the teeth that there will be no lateral strain. Theoretically, when the mouth is at rest there should be no strain upon the clasped teeth, because the upper plate (even though a narrow rim) should have sufficient adhesion by contact to sustain its weight, and the lower plate is held in place by gravitation; hence the clasps are a reserve force

Fig. 195

for work. Fig. 195, *a*, represents a broad, flat-spring clasp improperly adjusted. The linguocervical edge of the clasp rests upon the tooth, while the linguo-occlusal edge is somewhat distant from the tooth. When the arms of the clasp are bent inward so as to cause the clasp to grip the tooth, the linguo-occlusal edge will approach the tooth, and the base-plate, which represents the long arm of a lever, will be tilted away from the vault of the mouth, as shown by the dotted line. If the reverse of these conditions exists (Fig. 195, *b*), that is, the linguo-occlusal edge rests upon the tooth, and the linguocervical edge stands away from the tooth, then when the spring of the arms draws the clasp firmly to the tooth, the plate will be held securely against the vault of the mouth; there will be, however, a lateral strain upon

the tooth, tending to move the apex of the root of the tooth toward the vault. If either of these imperfect conditions is to exist, it had better be the latter, because the denture will be held firmly in place, and in time the tooth will be adjusted to the existing conditions; although sore during the orthodontic process.

Adaptation of the Clasps to the Tooth.—There are two methods of adapting clasps: (1) The clasp is formed by pliers to approximately a close adaptation, so that it will be uniformly supported yet not so close but that the fluids of the mouth can pass freely between the metal and tooth. (2) A piece of thin pure gold or platinum (36 gauge) is accurately fitted to the tooth; a strip of clasp metal is then adjusted as closely as possible with pliers to the burnished metal and the two united with wax; they are then sprung away from the tooth, invested, and thoroughly soldered together. It is possible, with this perfect adaptation of the clasps to the tooth, the secretions being retained by capillary attraction, and not changed by the fluids circulating in the mouth, that disintegration may be invited; but with proper cleansing and removing the denture at night almost no ill effects will present.

Forming the Clasps with Pliers.—Clasp gold is very crystalline, and when it is rolled from the ingot into plate the crystals are elongated into fibers. The metal is easily split between the fibers; across the fibers there is strength, flexibility, and elasticity, so for this reason the fibers should run lengthwise of the clasp, that is, around the tooth. Before forming the clasp the metal should be annealed by heating to a cherry-red heat and permitted to cool slowly.

PLIERS.

Two pairs of pliers are required. One (we will call No. 1) with hawk-bill-shaped beaks, the under smaller than the over beak and oval or round in its cross-section, while the over beak is flat on the under surface of its cross-section (Fig. 196). The other pair of pliers (No. 2) is the ordinary clasp-forming variety, having a rounded and a concave blade

(Fig. 197). No. 1 pliers is for general utility, and with it most of the shaping of the clasps is done. It gives the concavoconvex form to the cross-section of the clasp, and in

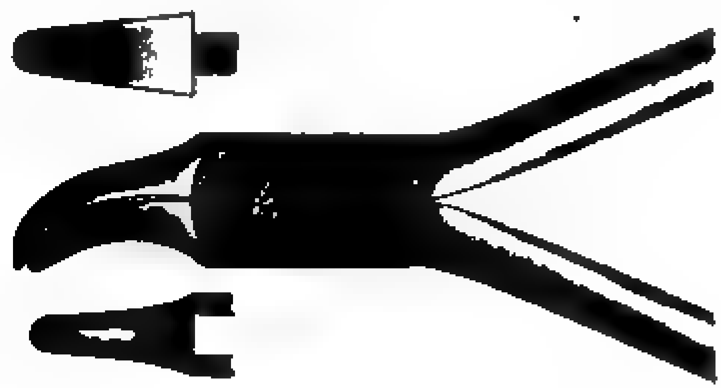

Fig. 196

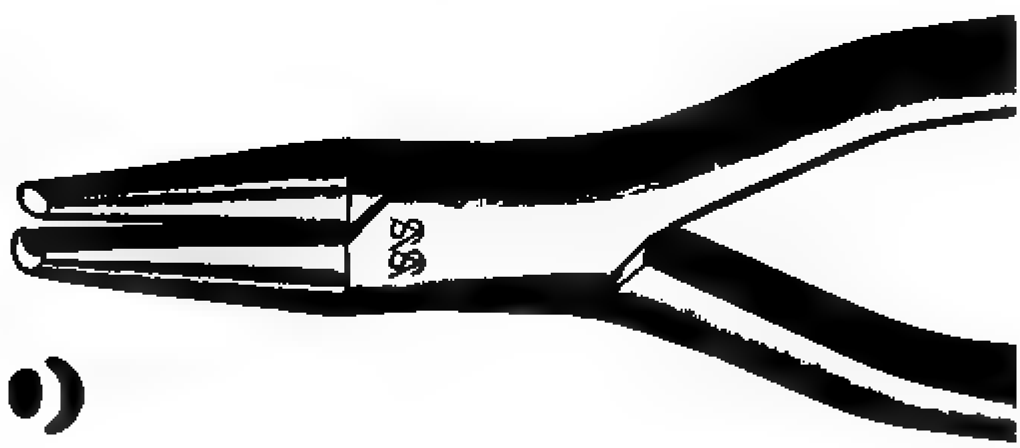

Fig. 197

Fig. 198

Fig. 199

connection with the fingers give the general outline of the tooth. The No. 2 pliers is better adapted to bending the clasp to sharp angles, depressing a bulging portion or denting the edge of a clasp.

Attaching the Clasp to the Plate.—In gold work the clasp is either soldered to the plate (Fig. 199, *a*), or connected to the plate by means of one or two standards (Fig. 198, *a* and *b*). For vulcanite work a tang is soldered to the clasp (Figs. 185 and 189), after which the base-plate may be extended any distance to grip the tang. Fig. 189 shows union of clasp and tang.

LOCATION OF ATTACHMENT UPON CLASP.

The attachment to the clasp should be one-eighth to three-sixteenths of an inch wide, and should be placed as near the middle of the long way of the clasp as the setting of the teeth will permit. By this arrangement a spring clasp will not be converted into an unwieldy stay clasp. Fig. 198, *a*, shows the right way to form the attachments, while Fig. 198, *b*, illustrates a wrong way.

FIG. 200

Flasking.—Clasp dentures may be best flasked in the wide rim of the Star or Wilson flask. Often a special flask, as the Whitney 18 A (Buffalo Dent. Mfg. Co.), is the most efficient.

Fig. 200 illustrates the sections of the Whitney 18 A, and (Fig. 201) shows the flask in use.

Conclusion.—Clasps properly conceived and formed are a blessing to both patient and prosthetist, but improperly used are vexatious to the dentist and a detriment to the victim. The retention of artificial dentures either partial or full is a profound subject for thought, and worthy the best efforts of the prosthetist.

Fig. 201

CEMENTATION

This term is used to denote that an adhesive substance, as cement, is used as the means of retention for crowns, bridges, and the so-called "alveolar dentures." Crowns and spanning bridges are clearly out of the scope of this book, while removable bridge-work is on the border line between bridge-work and plate-work. A spanning bridge with one or more saddle abutments is clearly a bridge. A saddle extending under the entire denture is but an extension of the saddle abutment, therefore there is no clear line of demarcation between bridge-work and plate-work. However, a base-plate, of whatever material, depending upon telescoping crowns, bar and slot, tube and split pin, or a pin or ball with slit-tube attachments, are so intimately associated with

crown-work that they may be justly classed as removable bridge-work. Nevertheless the trend of the times is to a growing interest in partial plate dentures, and as there is not a very wide distinction made in practice between plate prosthetics and crown prosthetics the writer is justified in mentioning some of the crown and inlay attachments used as retainers for partial plate dentures. However, the student should consult his text-book on crown and bridge-work for instruction regarding the crowns of which the special attachments under consideration are a part, and the technic for their use. The writer does not wish to be understood as indorsing the following methods, for he does not make use of any of them, and believes that Hunter's exposé of "Septic Dentistry" and the teaching of the research workers of the profession will eventually drive the greater part of the present crown and bridge methods from general practice; also that during the transition period to simple plate work he presumes that crown and inlay attachment may be quite in vogue with the profession.

It does seem that the locking devices must be at their zenith for all three of the geometrical figures—square, triangle and circle—have been variously utilized. These attachments are all based upon the principle of the mortise and tenon, and, are held together by friction and by inlocking. In some of the devices the mortise is in the plate, and others have it in the anchor tooth. Some of the inventions are rigid and unyielding, others have a limited amount of resiliency; therefore the prosthetist desiring to make use of such expediency may choose from an imposing collection.

The following illustration will serve as a study of some of the numerous devices on the market, and methods advocated. When studying any device the student should give careful attention to its effectiveness as a retainer; strength of all the parts involved, for the device may cause a weakened plate or anchorage; effect upon the health of the anchor tooth and adjacent tissues; and the septic conditions involved.

The three cardinal principles desirable in any device or method are simplicity, durability and cleanliness.

Fig. 202 shows the Condit paralleling appliance, which is

the prototype of all paralleling appliances. It consists of two bars, one of which is slotted and is attached to the other bar with a thumb clamping-screw. Each of these bars has, at one end, a right angle post which are necessarily parallel to each other. One of the posts is thread-cut, so as to be adjustable. These posts hold the split tube of the Condit stop-pin attachment parallel while adjusting to the crown supports of the removable plate-bridge. A third post is shown in the cut, which is a long-pointed thumb-screw to aid in supporting the jack while attaching the slit tubes. Any mechanician can construct this jack or adapt posts suitable for the various retaining devices.

FIG. 202

Fig. 203 shows the Condit stop-pin (enlarged) both united and separated.

Fig. 204 shows the Morgan attachment: also a completed denture ready to slip into place.

Fig. 205 shows a jack used for paralleling the Morgan attachments. This jack may be used for mounting any of

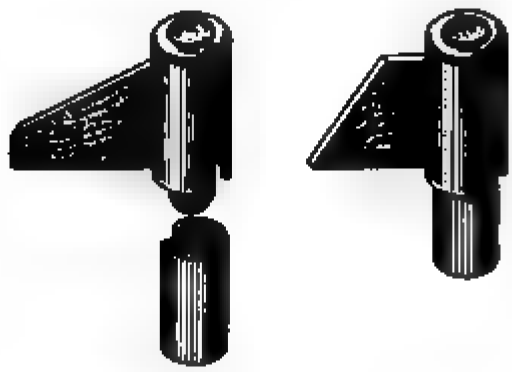

Fig. 203

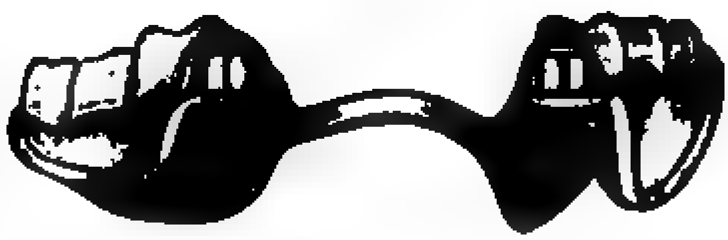

Fig. 204

Fig. 205

FIG. 206

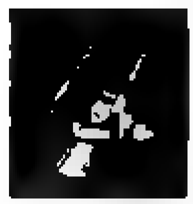

FIG. 207

FIG. 208

FIG. 209

the various attachments, provided suitable clutches are obtained for the specific device.

Fig. 206 shows the Gilmore clip, as used, and completed saddles. Saddles of this type should be joined to a similar one on the opposite side of the jaw, or, to an inlocking device at some distant point.

Fig. 207 shows the Gilmore clip enlarged.

Fig. 208 shows the Roach ball and slit tube. Fig. 209 illustrates its use in connection with a contact bar. This attachment is probably the most resilient and has the greatest scope for use and for cleansing of any of the marketed devices.

Except to condemn, the atrocities perpetrated under the alluring name "alveolar dentistry" are unworthy of consideration in any book.

CHAPTER VIII.

PORCELAIN TEETH.

History.—The late Professor Essig states, in the chapter on Porcelain in the *American Text-book of Prosthetic Dentistry;* that the history of the first use of mineral in place of animal substances for artificial teeth is wrapped in obscurity. One of the early recorded suggestions along this line is that of Guillemeau, in 1710, who proposed a paste compound of white wax, gum elemi, white mastic, coral, and pearl. Pierre Fauchard, in *Le Chirurgien Dentiste,* 1728, suggests the use of artificial enamel for this purpose.

The idea of "hard mineral teeth" is to be attributed to M. Duchateau, an apothecary of St. Germain-en-Laye, near Paris. He conceived the idea, in 1774, of constructing a plate in porcelain, molding it after the form of his ivory one. M. Duchateau took as an associate a dentist of Paris by the name of M. Dubois de Chemant. M. de Chemant improved the porcelain, and in 1790 obtained a patent from Louis XVI for his process. Dubois Foucou, dentist to the king, became interested in de Chemant's work, made improvements in the material, and made public the first description of the method for making mineral teeth. In 1808 Fonzi, another dentist of Paris, first made separate individual teeth, and also baked small pieces of platinum in them to serve as a means of attachment to the plate.

De Chemant moved to London in 1791 and became associated with Cladius Ash, and for many years experimented in and manufactured porcelain teeth.

Porcelain teeth were not introduced into America until about 1817. The first use of them of which we have knowledge was by A. A. Plantou, a Frenchman, who began the practice of dentistry in Philadelphia about that time. He commenced the manufacture of mineral teeth about 1820.

Charles W. Peale, in 1822, and Samuel W. Stockton, in 1825, were the next after Plantou to manufacture porcelain teeth, and they were soon followed by many others. By the year 1838 mineral teeth were in general use. About this year Dr. Elias Wildman, of Philadelphia, succeeded in improving the material, so that it would stand the high heat of soldering, and the texture and life-like appearance to such an extent that it has been said that it remains unexcelled to the present day. To him has been accredited the honor of placing the manufacture of porcelain teeth on a scientific basis.

COMPOSITION OF PORCELAIN.

Definition.—Porcelain is divided into three classes, as hard, natural soft, and artificial soft. Dental porcelain belongs to the subdivision hard porcelain, and may be defined as: A solidified suspension of one or more unfused silicious substances in a fused silicate. Porcelain is high or low fusing, dependent upon the quality and quantity of the basic ingredient. The material commonly called glass is fused silicious salts; therefore all porcelains may be converted into glass by sufficient fusing.

Materials.—The materials entering into dental porcelain are feldspar, silica, kaolin or clay, alkalies, and pigments. The pigments used are made of titanium, cobalt, iron, tin, gold, and platinum.

Feldspar.—This is generally spoken of as a double silicate of aluminum and potassium, and is represented by the formula Al_2O, K_2O, $6SiO_2$. The best feldspar is found in the neighborhood of Wilmington, Del. It presents a distinct cleavage, and when broken splits into plates of more or less magnitude. It is of an indefinite color, between yellow and pink, but when fused in the furnace it becomes transparent and colorless, and if not exposed to a too prolonged or an excessively high temperature it retains its original form without rounding at the corners; this is one of the tests of good feldspar. There are several deposits of this mineral in eastern Pennsylvania, which, though beautiful and transparent in appearance, have been found to be entirely unfit

for dental porcelain because of their opaque-white color when fused in the furnace. The preparation of the spar consists of selecting suitable rock (some of the spar from a good quarry will not answer for dental porcelain), breaking it into fragments with a steel hammer, and grinding it into powder in a Wedgewood mortar. The material is sifted at intervals through a No. 10 bolting-cloth sieve. The grinding should not be carried too far, or its translucency may be greatly lessened.

Silica (SiO_2).—This material, sometimes called quartz, occurs in crystalline and amorphous forms; it is colorless, infusible at ordinary temperature, insoluble in water and all acids except hydrofluoric. The amorphous and gelatinous varieties are partially soluble in alkaline carbonates, but quite soluble in caustic alkalies. Silica combines with the bases to form silicates.

The purest natural form of silica is the transparent and colorless variety of quartz known as rock crystal. Without transparency and crystalline structure, silica is met with in the form of chalcedony and carnelian, agate, cat's eye, onyx, opal, and other precious stones. Sand, of which the white varieties are pure silica, appears to have been formed by the disintegration of silicious rock. The yellow and brown discoloration is due to the presence of oxide of iron.

Silica is used for the purpose of giving stability and firmness to porcelain, and its infusibility stiffens and keeps the other materials in shape so that an object made of porcelain may preserve its molded form while exposed to the high temperature during the process of firing. For these reasons it is incorporated with feldspar and clay, and is looked upon as the "main prop in tooth body."

The quartz is crushed and ground in a Wedgewood mortar until it will pass through a No. 10 bolting-cloth sieve, when it is reduced, under water, to an impalpable powder.

Kaolin.—Kaolin is the purest quality of clay freed from such impurities as sand and mica by careful washing. It is a hydrated silicate of alumina, and may be represented by the formula $(2Al_2O_3, 3SiO_2) + H_2O$. It is formed by the long-continued action of air and water upon granite and

feldspar rock. The disintegration is probably due to both mechanical and chemical causes.

Clay is infusible in an ordinary furnace when heated alone, but readily unites with feldspar at a high temperature. It is an element of strength in porcelain.

German clay is imported from Europe and is probably the most infusible of the clays.

Alkalies.—Both of the alkali metals potassium and sodium are used as fluxing material. Potassium is an essential element of porcelain. Sodium could not be substituted for potassium because of the green tint it imparts to the product; but in conjunction with potassium it is a valuable addition, because it increases the fusibility without increasing the amount of alkali. The potassium and sodium salts are all soluble in water. It is evident that this property in artificial teeth is undesirable, but concomitant with the lowering of the fusing-point of the porcelain. Therefore it is logical to conclude that the higher the fusion of the porcelain the less soluble, and the lower the fusion the more soluble. In other words, the high-fusing porcelains are practically insoluble, whereas the low-fusing are liable to etch and disintegrate in the fluids of the mouth. Undoubtedly the modern makes of artificial teeth are sufficiently high fusing to be insoluble in the mouth; but the porcelains placed upon the market for the dentist's use in constructing bridges, crowns, and inlays, excepting the highest fusing ones, are dangerously near the etching point. Material has been placed upon the market so loaded with flux (alkali) that they soon prove to be unstable. In using low-fusing porcelain, to be placed in the mouth, this property of solubility (etching) must be taken into account; as low fusion can only be produced by adding flux (however, excessive pulverizing lowers the fusing-point, also injures the texture), and the more flux the more soluble.

It is interesting to study the four essential elements entering into porcelain—oxygen, silicon, potassium, and aluminum; one gas and three solids; two non-metals and two metals. Of the three solids, silicon melts at 1500° F., potassium at 144.5° F., and aluminum at 1200° F. Oxygen is

the most abundant and silicon second most abundant element, while aluminum is the most abundant of all metals. Silicon combined with oxygen (silica) is almost infusible and insoluble, and there is almost no expansion or contraction by heat. Aluminum combined with oxygen (alumina) is highly refractory and non-changeable. Potassium combined with oxygen forms potassa; it fuses at a low temperature, and is very soluble in water. Silica combined with alumina forms kaolin (clay), is refractory, easily hydrated, and contracts in heating. Silica and alumina combined with potassa form feldspar, which material forms the largest portion of artificial teeth.

Pigment.—The pigmentary substances, titanium, cobalt, iron, and tin, are used in the form of oxide; gold is used both as an oxide and in the metallic state; and platinum as a fine precipitate-platinum sponge.

Titanium oxide is the only pigment used in the "body porcelain." It gives the creamy yellow color of the dentin. It is also used for the yellow color of enamel.

Cobalt oxide produces the blue tints of enamel.

Iron oxide is used for certain gray tints.

Tin oxide is used only in combination with gold oxide as purple of Cassius to produce the pink gum color.

Gold is used in the metallic state for reddish-brown tints in enamels.

Platinum sponge produces gray tints.

THE PROCESS OF MANUFACTURE.

The process of manufacturing artificial teeth consists of (1) preparing the stock material, (2) molding, and (3) firing.

Stock Material.—The stock material is first worked up into four forms, as body, frit, flux, and enamel.

Body.—The body represents the dentin of the natural teeth. It is the highest fusing portion of the porcelain. It is composed of feldspar, silica, kaolin, and titanium oxide, with a small amount of starch to make the material plastic for molding.

Each manufacturer has his secret formulæ, but the fol-

lowing formula gives an idea of the proportions of the ingredients: Kaolin, 1 ounce; silica, 3 ounces; feldspar, 18 ounces; titanium oxide, 65 grains; starch, 10 grains to each ounce.

Frits.—The frits are the colors prepared for the enamels. They consist of the pigment substance mixed with feldspar and flux ground exceedingly fine, fused into a glass and reground for use. A typical formula would be: Platinum sponge, 1 pennyweight; feldspar, 1 ounce; flux, 20 grains.

Flux.—Used to lower the fusing-point of enamels and porcelains. A good formula is: Silica, 12 ounces; glass of borax (sodium borate), 3 ounces; potassium carbonate, 3 ounces.

Enamels.—Enamels are composed of feldspar to which has been added a sufficient quantity of frit and flux. A typical formula for enamel is: Feldspar, 1 ounce; gold frit, 6 grains; platinum frit, 4 grains; flux, 20 grains.

Molding.—Artificial teeth are made in brass molds. As porcelain shrinks in firing, the desired tooth is first carved in plaster in enlarged form. From these enlarged forms brass molds are produced. Figs. 210, 211, 212, and 213 illustrate the molds used for two sets of fourteen upper teeth. The molds are made double for convenience in keying the parts together.

The brass molds are oiled and the platinum pins placed in the little holes on the pin side of the molds. The point enamel is then put in the face side of the mold and arranged with a small spatula to the full thickness at the point and tapered down sparingly toward the neck. A thin coat of point enamel is placed on the lingual side of the front teeth and on the masticating surfaces of the bicuspids and molars. Some makers of teeth use but one enamel; instead of applying a yellow neck enamel, they allow the body to show at the neck of the tooth; this is probably done to save time and labor, but it does not afford the best results as to translucency and natural appearance.

The body is applied in small pieces slightly in excess of the quantity needed for each tooth. These are picked up with a small spatula, formed into balls, and laid on the pins

Fig. 210

Fig. 211

Fig. 212

in the pin side of the mold. The two sides of the mold are then placed together and heavily pressed. The mold is then removed from the press, put in an iron clamp, and secured firmly together; it is then heated on a stove until the mold becomes hissing hot, after which it is removed and allowed to cool sufficiently to handle. The mold is then opened and the teeth dislodged and removed by striking the mold with a wooden mallet. If the heating has been carried to the proper point, the teeth will be hard enough, through the agency of the starch in the formula, to admit of trimming. This is done with fine files.

Fig. 213

Burning.—In manufacturing on a large scale the blocks are arranged in complete sets on a fire-clay slide covered with coarse quartz. These slides are $6\frac{1}{2}$ inches in width by $9\frac{1}{2}$ inches long; they have raised edges to retain the quartz, which serves as a bed for the teeth.

The furnaces used by the large manufacturers have a capacity of three or four hundred sets per day for each furnace. The furnace has a heating oven over the muffle. The muffle is constructed of the best fire-clay, 27 inches long, 8 inches wide, $5\frac{3}{4}$ inches high, and $1\frac{1}{4}$ inches thick.

The muffle must be thoroughly swabbed with clay, mixed thin with water, to fill up all cracks or defects through which the gases from the fuel might enter the muffle. Such accidents are of frequent occurrence in burning, and are always ruinous to the teeth, the gas generally imparting to them a ghastly blue appearance. The furnace has a flue at the top connected with a smokestack, and is heated with oil.

The slide containing the teeth is placed in the heating oven at the top of the furnace before burning; this preliminary heating prepares them for the higher temperature of the muffle. The length of time required for burning the teeth varies with the heat of the muffle. About fifteen minutes is usually required. A too rapid heat tends to burn out or vaporize the color of the enamels. The proper glazing of the teeth is ascertained by placing under a gas jet. When the burning is satisfactorily accomplished they are put in the cooling muffle, protected from air drafts, and left undisturbed until quite cold.

CLASSIFICATION OF PORCELAIN TEETH.

Porcelain teeth may be divided into two general classes, namely, plain and gum teeth. In the former the crown of the tooth, and sometimes a portion of the root, is represented, whereas in the latter class the labial and buccal gum is added to the crown. The base upon which they are to be mounted and the means of attachment to the base further divides them into classes as follows:

Plain Teeth
- Vulcanite teeth (Fig. 214).
- Plate teeth (metal work) (Figs. 215, 216, 217).
- Continuous gum teeth (Fig. 218).

Gum Teeth
- Gum section teeth (for vulcanite) (Figs. 223 to 226 inclusive).
- Single gum teeth (for metal work) (Figs. 227 and 228).

Attaching Teeth to Base.—The means by which the porcelain teeth are attached to the base-plate upon which they are mounted is usually two platinum pins, the headed ends of which are imbedded in the substance of the teeth and firmly fixed in it when the porcelain is baked. Platinum and porcelain have very nearly the same coefficient of expan-

Fig. 214

sion, so that in a similar range of temperature they approximately expand and contract alike, and there is small danger of a cracking of the tooth or a loosening of the pin. It must be remembered, however, that the capacity for absorbing heat differs greatly with the two substances, platinum having a much higher specific heat, which fact, coupled with its greater conductivity, makes it necessary that a greater amount of heat should be applied to the porcelain when teeth are subjected to high heat. The platinum does not fuse at the high temperature necessary to the baking of the

Fig. 215

Fig. 216

body of the tooth, and its non-oxidizable surface makes it possible for the porcelain to adhere to it with considerable tenacity. One manufacturer alloys iridium in small amount with the platinum to give the pins greater rigidity and tensile strength.

The great cost of platinum has been responsible for many

attempts either to substitute other and less expensive metals for it, or to reduce the amount of metal used for the attachment in the tooth, or to dispense with the pins altogether. The less expensive metal usually employed is nickel or some of its alloys, but as these readily oxidize during the baking, the intimacy of the union between pin and tooth cannot be so close as where platinum is used. The discoloration of

FIG. 217

the tooth from the dissolved oxides of the pins is frequently sufficient in amount to be objectionable, and the low-fusing body which is necessary with teeth if this sort is not so strong as that which may be baked on platinum pins. The attachment of pins of base metal to platinum anchorage baked in the tooth by soldering the pin to the anchorage is an ingenious method adopted by one manufacturer to reduce the amount

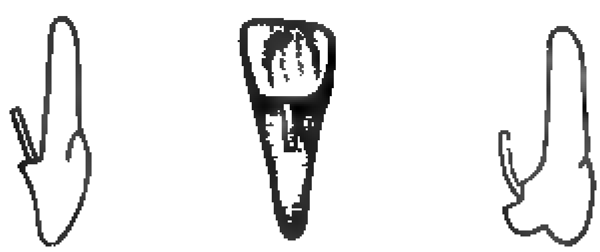

FIG. 218

of platinum (Fig. 219). The anchorage is in the form of a tube imbedded in the porcelain, the inner end of which is expanded into a flange which is for firm retention. The pins of alloy are made to fit the tubes and are soldered to them with high-grade solder, and tests seem to have proved that the teeth are strong enough for satisfactory service.

The construction of teeth whose attachment is by means of an undercut recess in the tooth filled with the plastic base upon which they are mounted is another attempt to reduce the cost of production by doing away with the platinum entirely. They are called "pinless" and "diatoric teeth." The mechanical difficulties in the construction of a tooth of this type, until recently, which shall be sufficiently strong, have limited their use practically to the bicuspids and molars, in which positions under favorable conditions they are eminently satisfactory.

Fig. 219.—*a*, base metal pin; *b*, platinum anchorage; *c*, expanded end of same.

Forms.—The forms of porcelain teeth are determined by three factors. The most important of these is the anatomical characteristics of the teeth they are to substitute. As only the crown is represented, the labial or buccal surfaces, the morsal surfaces, and such portions of the approximal surfaces as are presented to view, are patterned after the natural teeth. Teeth quite satisfactory in this respect are manufactured today, although the market contains many made according to old designs which are poor imitations of the natural organs. The form of the incisors and cuspids is in general much better than that of the molars and bicuspids, the occlusal surfaces of many of which are too narrow for

the best masticatory results, the cusps are too poorly defined, and no attempt is made to have those of opposing sets fit together.

The shape of the other portions of the teeth is determined by considerations relative to their attachment to the base upon which they are mounted, and by the mechanical requirements which the shape and relation of the jaws impose. Teeth for rubber and celluloid work are similar in design. When the latter came into use the artistic possibilities of the new material created a demand for more natural forms in teeth, and so-called "celluloid" teeth were designed to meet it. Teeth of this form may also be used with a cast-metal base, but they are all designated rubber teeth.

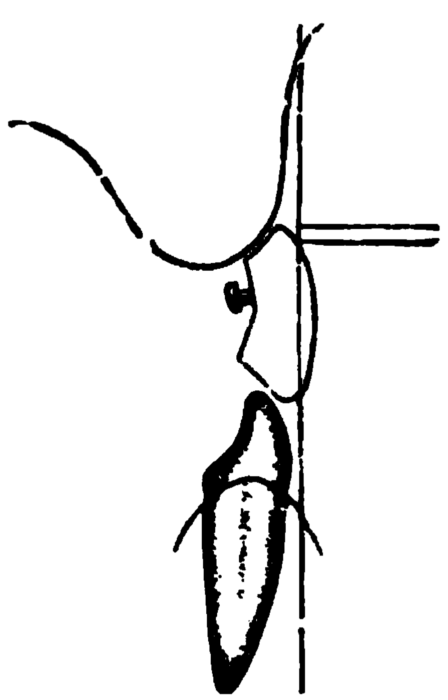

Fig. 220

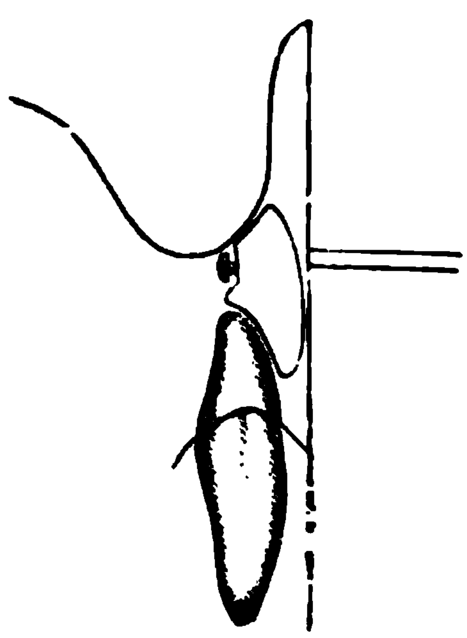

Fig. 221

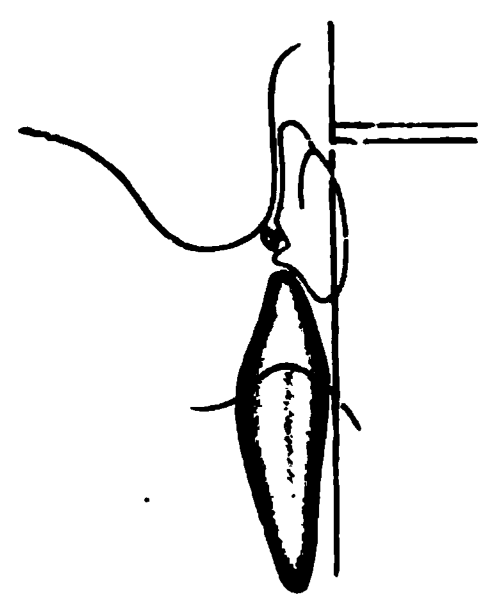

Fig. 222

Plain rubber teeth are provided with two-headed pins to secure their attachment to the vulcanite. In the incisors and cuspids there is the so-called "pin-guard" situated between the pins and the morsal edge to afford a shoulder to which the vulcanite may be finished. The "ridge lap" (Figs. 220, 221 and 222) is that portion of the tooth which comes into relation with the alveolar ridge, and may be long or short in accordance with the requirment of the case. The "bite," or "overbite," as applied to incisors and cuspids, is that portion of the tooth intervening between the pin guard and the morsal edge. The "shut of the jaws" refers to the dis-

tance between the jaws when the mandible is in the proper position for the occlusion of the artificial teeth. Thus, where the distance is marked we have a "long shut," which demands the use of a tooth that will fill in the space, and hence is known as a long-shut tooth. A long-bite tooth would fill in the space, but it would throw too much strain upon the pins to remove them so far from the point of stress. The bite, shut, and ridge lap, it will be seen, are all correlated.

Countersunk pin teeth were introduced about 1885. Their lingual surface corresponds in shape to that of the natural teeth, the attachment to the molded base being by means of pins located in a depression in their base. Their close conformity in contour to the natural organs makes them more acceptable to the tongue than teeth backed in the ordinary way, and renders articulation easier and more distinct.

Inasmuch as they must be mounted almost over the alveolar ridge, they cannot be used in cases with a short shut.

For a vulcanite base the case should be flasked in the usual way, but in packing each countersink should be carefully filled with small pieces of rubber to insure the rubber being thoroughly forced into the countersink and around the pins.

Plain plate teeth are designed for use on a metal plate or in crown-and-bridge work. The incisors and cuspids, in either instance, are similar in form, but those for use in the bicuspid and molar region for crown-and-bridge work represent only the buccal surface of the tooth, and are sometimes known as "veneers."

Continuous-gum teeth are illustrated in Fig. 214. It will be seen that they have only one long pin, and that the buccal and labial portions of their roots are represented in porcelain. This contributes to the firmness of their attachment to the base, the porcelain body fusing upon the roots and uniting them to the plate. It also maintains the contours of these regions by reducing the amount of porcelain body to be baked, and hence the shrinkage in this locality.

Gum Teeth.—Gum teeth are made for metal plates and for the plastic bases, those for the former being at this time made only as single teeth (Figs. 227 and 228), while those for

Fig. 223

the latter are usually in sections of two or more teeth and designated "gum section" or "block" teeth (Figs. 223 to 226 inclusive). The use of gum teeth is limited to those cases

Fig. 224

Fig. 225

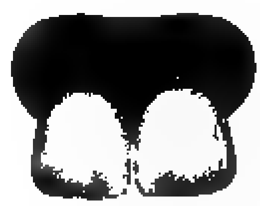

Fig. 226

in which resorption of the alveolar process has taken place to such an extent as to demand considerable restoration by means of the denture. With the exception of that found in

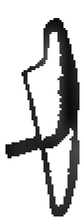

Fig. 227

Fig. 228

continuous-gum dentures the porcelain of gum teeth provides the best imitation of the natural tissues that has been

obtained, but the fixedness of the relation between the teeth in the section, and the difficulty of joining, particularly of the single gum teeth, are drawbacks which this does not overbalance. The artistic possibilities in arrangement which plain teeth offer have caused them to come into general use, and in most cases they are to be preferred. It must be remembered, however, that in some full dentures, and many partial ones, gum teeth may be used to great advantage. They are made in a variety of forms and offer a wide selection.

IMPROVEMENTS IN TOOTH FORMS.

In 1907 Dr. J. Leon Williams, of London, England, started a compaign in the dental journals for better tooth forms. The results are being seen, as some of the manufacturers are placing upon the market improved forms of bicuspids and molars.

Dr. Williams found it was no easy matter to induce the manufacturers, with their expensive equipment of molds and large stock of artificial teeth, to abandon their established methods, though unsatisfactory, and adopt a new system based upon an untried theory. However, being a man of a highly cultivated artistic personality and much determination, he resolved that the time was ripe for the much-needed improvements in artificial teeth, and that it should be brought about.

Since writing the text for the former edition of this book Dr. Williams has completely changed the scheme for his work. His scheme has evolved itself into a classification based upon his extensive anthropological studies, and is now in concrete form and obtainable as "Trubyte" teeth. Dr. Williams's studies have demonstrated that there are but three elemental forms of teeth, and that these forms are represented by the geometrical figures of the square, triangle, and circle. As all faces are but modifications of the three forms, if beauty is to exist, there must be harmony in the form of the face and teeth. Therefore a square type of face, whether long, medium, or short, must have the square type of tooth in its appropriately modified form;

the pointed-triangular face must have teeth with straight sides and constricted necks, and the round (oval and ovoid) faces require teeth with their outline made up of curves.

The scheme contemplates seven forms or modifications for each class, and 7 sizes of each form, or 49 models for each class, and 147 models for the 6 upper anterior teeth. It is presumable that the lower anterior teeth will not require so great a variety of forms of each class, but of each class form produced there must be a corresponding size for the upper. The forms of the teeth are marked in the carding wax with an Arabic numeral 1 to 7 inclusive, and the sizes by a letter. The sizes in Class I are indicated by the letters B to H inclusive; Class II, L to R inclusive, and Class III, T to Z inclusive; therefore the class to which a set of teeth belongs can always be told by the letter indicating the size. The models are charted in millimeters, giving the length of the central incisors and the combined width of the six teeth.

The surface markings of the teeth are evidence of the highly artistic sense of their designer, which in combination with their scientific coloring and shading must produce a degree of perfection never before attained in prosthetics.

The bicuspids and molars are developed upon an entirely different principle. While the anteriors are essentially esthetic the posteriors are remarkably effective in use. However, neither the anterior nor the posterior teeth are deficient in the factor in which the other dominates.

Professor Gysi has developed the system for the bicuspids and molars to be used with Williams's anteriors. It consists of but one form of three lengths and three sizes, making but nine molds. The occlusal surfaces are so perfectly formed that their antagonization is perfection and rarely will it be necessary to use a stone upon them. These teeth as carded are numbered to indicate the length and the combined width mesiodistally in millimeters. Professor Gysi has also produced a block consisting of the bicuspids and molars. These blocks antagonize as perfectly as the single teeth which they duplicate. Further, they are of the diatoric type, and where there is sufficient room to admit

of their use they will expedite the mounting of the teeth and probably give additional strength.

The system is so comprehensive that the dentist has only to make suitable occlusion models, take the required measurements in millimeters, select the color by number, and order by phone or letter.

DETACHABLE CROWNS FOR VULCANITE WORK.

Dr. Frederick H. Nies presents a method for using porcelain crowns of the detached-pin type (as the Davis, White, English tube or Goslee crowns) in vulcanite work.

The method consists of attaching crowns to a metal bar and posts, thereby producing the lingual bulbous portion of the tooth in porcelain and reducing the vulcanite baseplate to a minimum in bulk. Logically this method is suitable only for well-resorbed and receded processes, in connection with which the method has some valuable features, also presents some difficulties in antagonization and esthetics. The crowns may be attached to the posts with either vulcanite or cement; but in either case the countersink in the crowns should be roughened by grinding.

TECHNIC.—As each tooth is ground to the cast the post is inserted and the tooth and post waxed in place. The case is flasked and the wax removed. The anchor bar is now shaped to lie directly over the post holes, the loops in the posts having been gone over to see that they occupy as even a horizontal plane as possible. The fourteen posts are now strung on the bar in their places to fit the teeth to which they are adapted. The post holes in the crown are then partially filled with rubber or oxyphosphate. The posts, strung on the bar, are now pressed into each tooth to which they were adapted. The case is then packed with rubber and finished in the usual way.

Another method is to nearly fill the post holes with whiting—to prevent the red rubber running in—then insert the pins, pack and vulcanize. When finished the teeth are easily removed from their sockets and the holes cleaned of whiting. The teeth are then recemented onto the plate.

Fig. 229

Fig. 230

Fig. 231

Fig. 229 illustrates the posts strung on the bar.

Fig. 230 shows the posts strung on the bar inserted in the teeth.

Fig. 231 is the finished case.

PROTESYN.

The De Trey Brothers of Zürich, Switzerland, have invented a silicate cement gum facing for artificial dentures that will meet certain contingencies. It is especially indicated where considerable bulk of gum material is needed for lip contour, and the lip is very mobile. In such cases this material is second only to continuous gum dentures, which are often prohibitive.

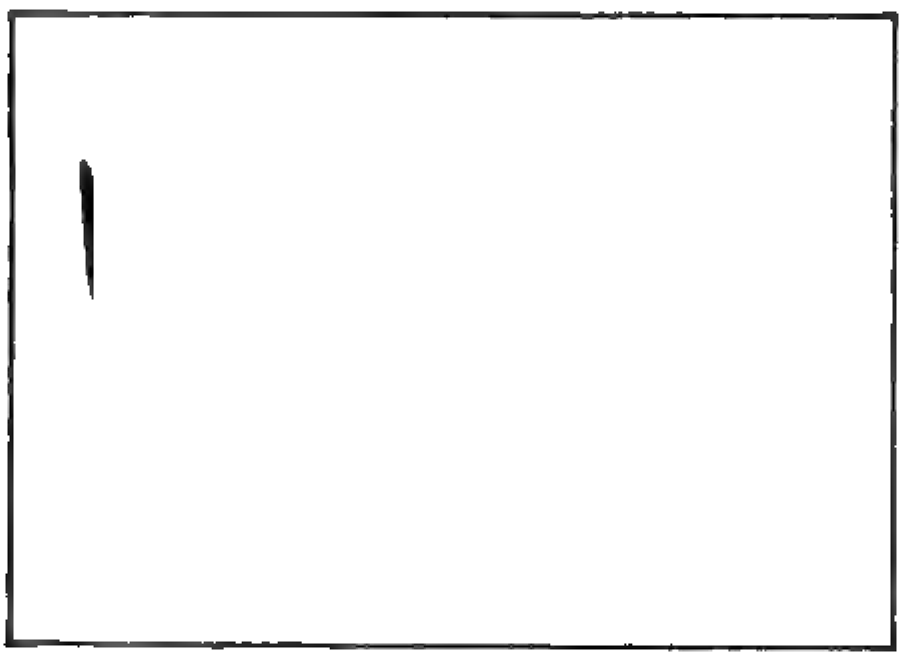

Fig. 232

The method is simple and very pleasing effects may be produced with it. However, it adds nothing to the strength of the denture and has not the durability of pink rubber; therefore it should not be used indiscriminately; nevertheless it is a valuable addition to the dentist's armamentarium.

Fig. 232 shows a denture properly prepared for placing the cement. There should be undercut space at the peripheral

border of the base-plate and at the cervical ends of the teeth for inlocking of the protesyn. The protesyn should be

Fig. 233

mixed on a glass slab, with an agate spatula, into a stiff putty-like mass. A sufficient quantity should be mixed to complete the operation—not two or more mixes for a denture.

Fig. 234

The cement is applied to the surface to be covered, with the spatula, and pressed firmly into place with the fingers,

which are lubricated with cocoa butter. It is then molded into artistic form by the aid of spatulas and brushes, as shown in Figs. 233 and 234. It is then heavily coated with the lubricant (cocoa butter) accompanying each package. The lubricated denture should stand twenty-four hours, when the butter is thoroughly washed away. Thereafter the denture must always be kept submerged in water when not in the mouth. To permit the protesyn to become dry injures both its color and texture. As the protesyn is very slow setting—twenty to twenty-five minutes—the operator has sufficient time to nicely adjust and manipulate the material.

Protesyn is furnished in three shades: light, medium, and dark; and it may be removed and renewed as often as desired. However, its replacing should seldom be required, provided it is well applied and kept clean and *constantly moist.*

CHAPTER IX.

DOUBLE VULCANIZATION METHOD.

In the preceding chapters the underlying principles, the nature, and the requirements for artificial dentures has been discussed. Chapter VI treats of the history, appliances, and primitive method of vulcanite construction, while this chapter presents an advanced technic of construction. By double vulcanization is meant that a vulcanite base-plate is made, and to it the superstructure is added at a second vulcanization. The advantages of this method over the single vulcanization method is that it provides a perfect fitting base-plate, provided the impression was a good one; and it very much facilitates the developing of the esthetic or cosmetic effects of the artificial denture.

TECHNIC.

The method consists of taking the impression, making the cast, making the base-plate, obtaining the occlusion and contour models, arranging the teeth, and proving the contour and expression; of preparing the case for flasking, packing, vulcanizing, and finishing.

Impressions.—It is imperative in this as in all kinds of artificial dentures that a perfect plaster impression be obtained. The technic of this operation is described in Chapter II.

Cast.—Because of the heavy pressure to which the cast will be subjected in molding the rubber, it should be made of a material that cannot be easily compressed. Spence plaster compound is best for this purpose (see Chapter III).

Base-plate.—The vulcanite base-plate is constructed as described on page 159. The base-plate should be con-

structed of the purest rubber, as Dougherty's pure black rubber, Traun's uncolored rubber, or Ash's dark elastic rubber.

Fig 235

Fig. 236

Occlusion and Contour Models.—The occlusion and contour models are constructed as described on page 160. The models are mounted on the New Century Antagonizor by

aid of the Snow face bow (Fig. 73). Any other anatomical antagonizor may be substituted.

Mounting the Teeth.—The teeth are mounted as directed in Chapter VI (page 253). The patient is about sixty years of age and of the sanguine modified by the nervous temperament. The teeth selected for the case were S. S. W. "natural forms," mold No. 227, Shade No. 40. It will be observed that the teeth are of sufficient length to nearly fill the space between the high- and low-lip lines, so that when the lips are parted to their farthest, only a slight trace of gum restoration will be observable—so slight, indeed, that the material should not be noticeable.

The overlap may be seen in Fig. 235. The lateral inclination, compensating curve, and diverging straight line are shown in Fig. 236. The esthetic features may be studied in Figs. 235 and 236.

Proving the Contour and Expression.—This phase of the subject is discussed in Chapter XVI.

Preparation of the Case for Flasking.—Strings are used for outlining the festoons and periphery of the gum. The object of the festooning string at the cervical portion of the teeth is to give the proper thickness to the margin of the gum. The string used for this purpose is waxed dental floss, twisted very hard, doubled, and twisted again. In doubling, the loop will show the direction it should be twisted the second time. Wax the string well with softened wax and apply it by grasping the left heel of the plate between the fingers and thumb of the left hand, with the occlusal surface of the teeth upward; place one end of the string at the distal surface of the second molar, pressing it gently into the wax; outline the margin of the gum, using the wax spatula to carry the string well into the interproximal spaces. The peripheral string should be well-waxed wrapping twine, placed at the outer edge of the wax, and secured in place by melted wax made smooth with a hot spatula. Fig. 237 illustrates the usual manner of applying the strings. The peripheral string should be applied at the line of separation of the flask, and this must be, in cases of heavy restorations, at the widest portion of the wax model.

The next step is to cover the buccal and labial surfaces with a strip of No. 60 tinfoil. Instructions are necessary in applying the tin over the strings. The No. 3 instrument of the Evans set of carvers (Fig. 100) is especially adapted for adjusting the tinfoil. The strip of foil is placed over the

FIG. 237

wax and teeth and pressed as closely as possible with the fingers. The surplus tin is cut away with fine-pointed scissors. Two pairs are desirable, one straight and the other curved. The edge of the tin may be anywhere between the morsal ends and the middle of the teeth. The tin should be slit between each two teeth. Fig. 238 shows the tin trimmed and slitted. Hold the work in the left hand, seize

FIG. 238

the instrument by the hand grasp, rest the thumb upon the occlusal surface of the second molar, and burnish the tin closely to the tooth and against the festoon string. Continue this operation with all the teeth. After adjusting the tin about the teeth, the metal must be burnished over the

string to give the desired thickness of the gum and the contour of the festoon. This is done by holding the plate and burnisher in the same manner as before. The instrument must extend one-sixteenth of an inch beyond the string and at the same time must rest upon the body of the tooth while pressing the tin down over the festoon string. By this means a proper thickness and contour are given the margin of the gum, without forming an unnatural beaded edge. After all the teeth have been thus treated, the position of the plate should be reversed in the left hand, so that the thumb of the right hand may rest upon the periphery of the base-plate while burnishing the tin from the festoons toward the periphery. With a pair of sharp curved scissors

Fig. 239

trim the tin flush with the peripheral string, but do not permit it to overlap the vulcanite base-plate. The case is now ready for tinning the lingual surface. Use No. 60 foil, and if the vault is a high one, slit the tin from the middle of one side to the center. Place the inner end of the slit over the middle of the vault, and one edge of the slit along the raphé to the palatal border; press the side of the foil gently against the wax and teeth; press the other half of the tin, in the same manner, into position, permitting the slit portion to overlap the first half. With sharp scissors trim the tin nearly down to the teeth. Remove the foil and place it upon a plaster or metal cast having well-defined rugæ, and burnish the rugæ into the foil. Remove the foil, turn it over, and fill the impressions of the rugæ with wax,

although the upper surface is spheroidal. The metal has the property of holding heat, so there is no need for undue haste, but no time should be wasted in getting the metal cast. The gas is turned off the gas stove, the bail is attached to the bucket, and as it is lifted from the stove the chain is made straight. The swinging of the bucket is started with a steady long swing, avoiding a jerk at the start of the swing. The diameter of the swing is quickly reduced to the limit and the speed increased. The motion should be continued until the metal has crystallized. This will probably require from fifty to one hundred revolutions.

Philosophy of the Casting Process.—By the swinging motion centrifugal force drives the molten metal down the feed gàte into the mold. By the law of physics (that liquids seek their level) the molten metal will rise in the mold and vent holes until it is on a level with the head of metal, when the centrifugal force will condense the metal until the hardness of the crystals of metal and centrifugence are equal. This will probably be when the metal has cooled 50° to 100° below its fusing-point. It is reasonable to suppose that the metal that has travelled the farthest from the head of metal will be the first to set, therefore the vent sprues and the palatal border would chill, and any contraction that is taking place will be made good by the molten metal under pressure backing it up, thereby keeping the mold full and providing a perfect fitting base-plate. The writer, by careful visual observation, has not been able to detect the defects in the castings made by this method that have been noticed in the castings made by other methods. Therefore the writer confidently presents the foregoing method as the best yet devised for casting aluminum.

Suggestion.—Sufficient free space must be provided for swinging the bucket, to preclude the bucket striking, and dumping the molten metal, thus endangering the operator and nearby property. Such accidents are inexcusable. It is well for an inexperienced person to practice with a small bucket filled with water and describing the same radius as with the casting outfit. Confidence will soon be gained in the ability to start and stop the swing of the bucket. If

mal spaces at the time the flasking is completed. The flask should stand about thirty minutes and then be placed over the stove in a stew-pan of cold water, to be heated up as before described on page 293.

Fig. 241

Separating the Flask.—When the heat of the water indicates the time for opening, the flask is grasped with a cloth holder in the left hand and separated by the point of a knife-blade or wax spatula inserted at the heel of the flask. The instrument should be guarded by the thumb and finger of the right hand to avoid the possibility of marring the case. The strings and as much of the wax as possible are removed with the spatula, after which the remainder is removed by pouring boiling water upon it; then with a cloth the tin lining and vulcanite base-plate are wiped dry (Figs. 241 and 242). The excess space is cut with small gate connections, provided the flask is to be bolted (Fig. 242), but no gateways if vulcanization is to be under spring pressure and the separated flask is placed over the sheet iron to warm as previously described (Chapter VI, Fig. 159).

Fig. 242

a

c

b

Fig. 243

Packing.—Sufficient Gilbert Walker's granular gum or pink rubber is cut into strips to form a layer of one thickness over the tinned surface. First pack a narrow strip of red rubber about the pins (Fig. 243, *c*), and small square or triangular pieces of granular gum between the cervical portions of the teeth. The strips of granular gum are then placed over the labial and buccal surfaces of the matrix with the fingers and wax spatula so that no space remains through which the red rubber can escape. The strip of red rubber about the pins should be pressed down with a wax spatula to form a symmetrical outline. A piece forming a half-circle of granular gum is then placed over the anterior

Fig. 244

portion of the lingual surface (Fig. 243, *a*), and with the wax spatula the circular edge is joined to the red rubber about the pins of the teeth. A piece sufficiently large when stretched to half its thickness (Fig. 243, *b*) is then applied over the remaining portion of the lingual surface, and its edges are united to the contiguous rubber. Red rubber may be substituted for the pink rubber of the lingual surface and give additional strength to the denture. Strips of red rubber are then placed over the teeth to nearly, but not quite, fill the mold. A separating cloth of closely woven cotton, or the cloth removed from the rubber after the sizing has been washed out, is saturated with warm water and placed over the rubber in the mold, when the two sections of the flask

are placed together. If the packing has been expeditiously done and the rubber is sufficiently warm, it is placed in the flask press and gentle pressure applied. The flowing of the rubber should be followed every ten seconds with a partial turn of the screw until the flask is closed. The flask is then removed from the press and separated. If there is not an excess of rubber, the cloth will easily separate from the rubber, but should there be strong adhesion, saturation of the cloth with water will facilitate its removal. Attention is again called to the danger of warping the denture while closing the flask. This is especially so with the double vulcanization method because of the small amount of rubber required to cover the lingual surface (see Chapter VI).

Fig. 245

Vulcanizing.—The case is vulcanized in the same manner as described in Chapter VI.

Finishing.—After washing to remove the loose plaster, the tin may be easily stripped off, and the excess vulcanite filed from the periphery of the denture. A sharp chisel should be used to trim about the labial and buccal surfaces of the teeth, but the lingual surface should be trimmed with a scraper. The file marks about the periphery of the plate should be removed with fine sandpaper. The labial, buccal, and lingual surfaces are buffed with felt wheels and cones carrying pulverized pumice and water. The spaces between the teeth are best reached with a stiff-bristle brush wheel, using wet pumice. All the surfaces, including the maxillary,

are glossed by using a rapidly revolving soft-brush wheel and whiting wet with alcohol or water.

Illustrations.—Fig. 244 is the completed case shown in occlusion. Fig. 245 presents the lingual aspect of the teeth and the reproduced rugæ. Fig. 246 shows the maxillary and mandibular surfaces.

Fig. 246

Conclusion.—The double vulcanization method is best adapted to full cases, but may be used in partial cases. The tin-finishing method is applicable to the single vulcanization method as well as to the double. It is the easiest and best method of forming the contour of the surfaces of the denture; also producing a dense surface on the vulcanite.

ing surface of any of the methods for finishing. Figs. 261, 262 and 263 show different views of completed dentures on aluminum base-plates. Fig. 264 shows the lingual surface of a denture with the metal cast to the teeth. Figs. 265 and 266 show the same case as the casting came from the flask.

Fig. 266

Casting to Porcelain Teeth.—The wax model must be so shaped that the cast metal will not overlap any edges of porcelain, because the contraction of the cooling metal may crack the porcelain teeth. The lingual surface of the denture must be carved to shape in the wax and smoothly finished. Chloroform can be used to finish the wax surface. The flasked case should be made very hot before pouring the metal; and then the case must stand until it is cold before removing from the investment. Platinum pin teeth should not be used, as the molten aluminum is a solvent for platinum. The labial and buccal surfaces are finished with vulcanite. Casting to the teeth is of doubtful expediency.

Fig. 267 shows the Elgin vacuum casting machine. Fig. 268 shows the method of forming the wax model and attaching the wax sprue. The process consists of drawing the

molten metal into the mold by exhausting the air in the mold, through the investment compound, with a pump. It is not reasonable to expect that a light and viscous sub-

Fig. 267

Fig. 268

stance like molten aluminum can be cast as sharply and densely, and with as much certainty, by negative force (suction) as by positive force (centrifugal). However, many operators are much pleased with the machine and its achievements.

FIG. 269

SWAGED ALUMINUM BASE-PLATE.

Aluminum may be swaged by either the die and counter or the machine method.

Die and Counter Method.—The student is referred to the chapter on Gold Base-plates for methods of constructing a die and counter; it is therefore only necessary in this chapter to discuss tersely the use of such a base-plate.

Formerly the most successful base-plate of aluminum was made by the swaging method, but with the advent of modern casting methods the order has been changed, and the writer cannot conceive of any case in which the swaged base of aluminum would be preferable. However, it is well to have a comprehensive idea of the manner of using such a base-plate.

A suitable die and counter having been formed, the die is oiled (sperm or lard oil) and a sheet of well-annealed No. 18 or 20 B. & S. gauged aluminum, with its fiber at right angles to the raphé of the mouth, is conformed to the die with a horn mallet, or, better, one tipped with soft vulcanite (a cane or crutch tip), and then swaged in the counter-die, using a heavy swaging hammer. The direction of the grain is important, as the base-plate is easily cracked, in use, if the fiber is parallel with the raphé. The base-plate having been adjusted to the mouth, the surface is prepared to hold fast the vulcanite used to attach the teeth by scoring the surface with an engraver, or by punching loops upon the surface. The scoring is done either with a hand engraver or an automatic mallet engraver. The loops are formed with a punch. These three instruments are shown in order in Fig. 269, and the work done by them is shown in Fig. 270. The base-plate is scrubbed with soap and water to remove oil and dirt, when it is ready to be used in forming the wax occlusion and contour models. It is flasked for vulcanizing the same as the cast aluminum base-plate. It is also polished in the same manner.

Machine Swaging.—Various machines have been devised for swaging metal base-plates; they are better adapted to the soft metals than to hard ones. The principal argument for their existence is their supposed simplification of constructing dies and counters; they certainly are not as effective as the die and counter method. However, there is a use to which they may be put in which the die and counter can-

Fig. 270

Fig. 271

not readily be used; that is, in reswaging a base-plate after attachments have been made to it. There are various types of these machines; however, Fig. 271 will suffice to illustrate these appliances. No. 12 shot is used for the counter die, and a heavy swaging hammer for the power.

CHAPTER XI.

GOLD BASE-PLATE.

Material.—Pure gold is a bright, rich, yellow metal, with a specific gravity of 19.26, and a fusing-point of 2016° F. It is the most malleable and ductile of the metals, and ranks third as a conductor of heat and electricity. It is insoluble in any of the ordinary mineral acids, but soluble in the combination nitrohydrochloric acid. It is not oxidized by heat alone, therefore is a noble metal. It is nearly as soft as pure lead, and can be alloyed with many of the other metals. It is used in prosthetic dentistry principally in its alloyed state. The metals with which it is alloyed for use in plate work are silver, platinum, copper, and zinc. Silver has little effect upon it, except to cheapen it and modify the color. Platinum alone with gold has little effect upon it, but in combination with silver and copper it makes the gold very hard and elastic. Copper alone hardens gold very much and gives a deep red-yellow color. Zinc makes it hard and brittle and increases the fusibility markedly.

There are two classes of gold used in plate-work known technically as *plate* and *solder*. The plate is that form of metal containing the properties of hardness or softness; rigidity, flexibility, and elasticity; high fusing or low fusing, according to requirements of the service to which it may be put. The two requirements of the other class (solder) are that it shall appear as near like the plate upon which it is to be used as possible, and melt and flow at a considerably lower temperature than the plate.

The precious metals are spoken of as so many carats fine, or so many parts of 24 pure; thus 18-k (carat) gold plate means that 18 parts of the 24 parts of the alloy are pure

gold and the remaining 6 parts consists of other metals. The required carats of gold for base-plates are 18-k and 20-k, with 22-k and 24-k for special purposes. A suitable formula for 18-k gold plate would be pure gold, 18 parts; pure silver, 4 parts, and pure copper, 2 parts. The 20-k and 22-k plate would have the indicated amount of pure gold with the alloying metals of equal amounts of silver and copper. The rigid and elastic plate known as *clasp gold* may be formed of any of the preceding carat by substituting platinum for half of the named amount of silver. Solders are formed of the same degree of fineness as plate by substituting zinc for a portion or all of the silver. This was formerly true of solders, but today, as the result of competition in trade, the solders are marked "for" the indicated carat plate. It is known that the solder is two carats lower than the number upon the solder.

The thickness of the gold plate should be governed by the method of construction, and the amount of stress to which it is to be subjected. For all full cases the gold should be 26 to 28 B. & S. gauges thick. (The metal decreases in thickness with the increase of number.) The thinner the plate the more essential it is that a wire should be soldered on outlining the vulcanite attachment. The wire to be 18 or 17 gauge and 20-k. A base may be swaged of 35-gauge pure gold (24-k) and entirely doubled with clasp or 18-k plate of 30 to 32 guage. The solder should be that marked "for" the lowest carat plate used in the appliance being constructed.

Methods.—Base-plates of gold are formed by both the swaging and casting methods. Swaged gold as a base for artificial dentures has been the standard from antiquity, and especially with the modern revival of dentistry. It is especially adapted to partial cases because of the ease with which it may be built up; its rigidity, strength, and compactness; and its purity and cleanliness. For most full cases it is inferior to continuous gum. The casting method for gold bases has but one feature in which it is superior to the swaged base of gold, that is, adaptation. In all other factors (excepting purity of material) it is inferior to the swaging

method. It is less dense, less rigid, less elastic, more bulky for the required strength, and consequently more expensive for stock.

TECHNIC FOR SWAGING GOLD.

Die and Counter Method.—The processes involved in this method are: Taking impression, making plaster cast (or, better, Spence plaster compound cast), model for die, die and counter, and swaging; making and soldering attachments.

Impression.—The student cannot be too strongly impressed with the fact that the first and most important element for success in any kind of prosthetic work is a suitable impression, and that the impression must be taken to meet the requirements of the individual case. (See Chapter II.)

Cast.—The impression may be filled with plaster, or, because of its strength and non-changing properties, Spence plaster compound. In filling the impression special attention should be given to developing the truncated cone form as directed in the chapter on Casts.

Model.—The model is the cast prepared for molding in the sand. The mold, with the exception of its face, that is, the surface made by the impression, must be so shaped that it will readily draw from the sand mold. This will require that the entire body of the model will slant outward to its base representing a truncated cone. This may be accomplished by cutting away unnecessary plaster and building out deficiencies with wax. The thickness of the model will depend upon the kind of molding flask used. If it is a ring flask, the base of the model should be one inch thick at the thinnest part to afford the required strength to resist crushing. If the molding is to be done in a Bailey flask (Fig. 272) or a Lewis flask (Fig. 273), or the die is to be used in a swaging machine, the base of the model need be but a quarter- or a half-inch thick. The base of a model so shaped could furnish no obstacle to its withdrawal from the sand mold (Fig. 274). The face of the model must next be studied, to know that it will draw from the mold, or that its

conformation is such that it will not be keyed in. It is evident that the face of the model cannot be carved to obliterate undercuts, but that means must be devised to reproduce

Fig. 272

Fig. 273

Fig. 274

the undercuts in the die. This may be accomplished by one of three ways—(1) by tilting the flask in drawing the model; (2) by the use of cores; and (3) by a specially constructed parting flask.

The first method answers well for a single slight undercut. This is illustrated in Fig. 275. The dotted lines represent lines of gravitation. It is apparent that if the flask is held at a sufficient angle the inlock is obliterated and the model may drop without defacing the mold. The slight undercuts that may be provided for by this method are located at the anterior portion of the alveolar ridge or at one of the tuberosities.

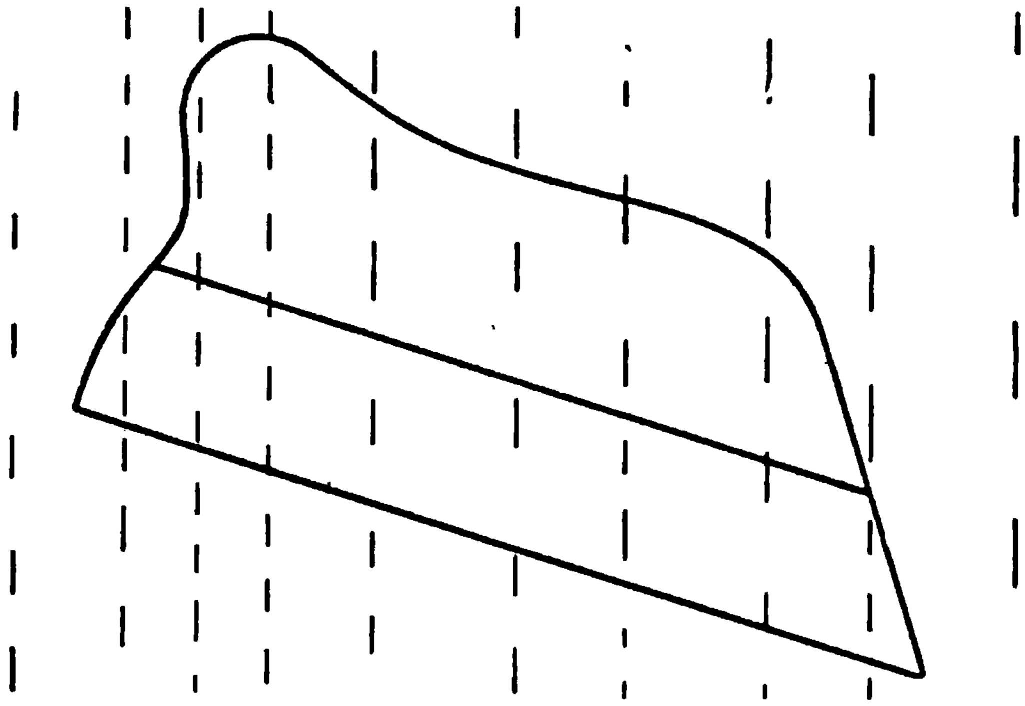

FIG. 275

The second method will provide for any and all cases that may present. The core is an added portion used to fill in the undercut and contour the model into a typical truncated cone. The model, having been varnished with shellac and sandarac (as desirable for molding), is built upon with a batter of investment compound (such as is used in cast aluminum work) to bring the model to the desired contour. For strength and convenience in handling, the core should be about one-half inch thick. It must be so trimmed that it will easily drop from the sand mold with the model; the core is to be returned to its seat in the sand mold and becomes a part of the mold. When the investment compound has

set it is parted from the model, trimmed as smooth as possible, and then placed in a warm place to dry. It should be

FIG. 276

dried to such an extent that a temperature of 700° to 800° F. will not drive steam from it. This can be done in an hour's

FIG. 277

time by standing it on its edge upon a sheet-iron over the gas stove. The core should not be placed on its side while

drying, as there is danger of warpage. Fig. 276 shows a core for the anterior undercut. Fig. 277 shows cores covering the entire labial and buccal surfaces of a model. The core may be constructed entire, and when set notched nearly through at the median line, and broken away from the model. The notch should be wide and smoothly trimmed. Fig. 278 illustrates cores for the lingual surface of a lower model.

Fig. 278

Third method: Figs. 279, 280 and 281 represent Hawes' parting flask. This flask consists of two rings, the bottom of which is hinged to part at three points.

Molding.—There are a variety of molding sands that may be used—the iron founder's black sand, the brass founder's brown sand, and marble dust. These materials require tempering for use. If the material is used daily it is best tempered with water, because of its cleanliness; but if it is only infrequently used, it is better to temper it with glycerin or sperm oil, as with these materials it remains ready for use

for a considerable time; however, the hot metal poured upon them produces a disagreeable odor. The material is mixed with the chosen liquid, thoroughly rubbed and sieved. They improve in temper by standing a few hours. If the molding sand is in a suitable condition it will not appear moist, but a handful thoroughly compressed in the hand will break with a clean fracture.

Fig. 279

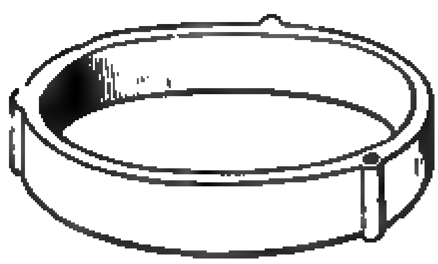

Fig. 280

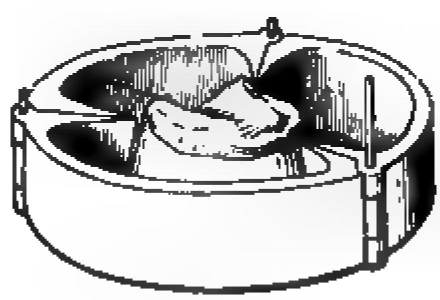

Fig. 281

Technic.—The model (with core in place if one is required) is rubbed with talcum powder, then placed upon a flat surface and encompassed with the ring of the chosen molding flask. Molding sand is sifted into the flask until it is one-third full. This is firmly packed with the fingers and a stick (tamping stick) about the model, more sand is sifted in and packed firmly down upon the face of the model. Sand is added until the ring is filled flush. The flask is lifted from the bench, turned over so that the base of the model is upward; a thin spatula or molding trowel is passed about the edge of the model to relieve it of any overlapping sand. The flask is again turned so that the base of the model is downward; if there is a slight undercut upon the model not supplied with a core, the flask must be held at such an angle as will release the model without dragging the mold. The

sand should be so firmly packed about the model that it will not drop of its own weight. The model is released from the mold by gently tapping upon the side of the flask with a light-weight instrument, as a wax spatula. If the mold is not perfectly clean and smooth at the first attempt, the operation must be repeated until a perfect mold is obtained.

Caution.—If the sand is overmoist it cannot be so firmly packed without generating steam under the hot metal and thereby spoiling the casting. This may be overcome by packing the sand less firmly, but if the sand is not compact enough the weight of the metal will give a distorted and useless casting. Therefore the student should not yield to the temptation to use insufficiently packed sand. He should use only well-tempered and well-packed sand.

Accessory implements that may be useful are: A 6-inch straight-edge to smooth the sand flush with the edge of the ring; a flat ½-inch ox-hair paint brush, and a small-mouthed blowpipe. If needed, the occasion will suggest their use.

Metal for Die.—A suitable metal for a die should possess hardness, toughness, sufficient fluidity to take a sharp imprint, and should be moderately low fusing, and non-shrinking. There are three types of metal used for dies, namely: (1) a shrinking metal (as zinc); (2) non-shrinking (as Haskell's Babbitt metal); and (3) low fusing (as the low-fusing bismuth compound).

Zinc.—Zinc is the hardest of the metals commonly used for dental dies, but it shrinks the most of any of the metals. The advocates of this metal contend that the shrinkage is an advantage, that it assures a close fit. This argument is illogical, for if an impression has been taken to meet the requirements of the case all subsequent procedures should require exactness and not counter-balancing changes. The late Professor Buckingham demonstrated that in an average-sized zinc die the shrinkage is about $\frac{1}{48}$ of an inch across and $\frac{1}{86}$ of an inch in length. Such a change would be almost intolerable upon thin, tense tissue or properly compressed soft tissues. However, the metal is much used for dies.

Babbitt Metal.—There are many alloys on the market known as Babbitt metal, some of which are little more than

lead, and all of the hardware store stock is unreliable for dental purposes. The alloy made after the formula of Dr. L. P. Haskell and carried by the dental-supply houses, meets the requirement. His formula consists of copper, 1 part: antimony, 2 parts; and tin, 8 parts (c-a-t-1-2-8).

Care should be used not to overheat this alloy; in fact, no base metal or alloy should be heated much beyond its melting point. There are two reasons for this: (1) Oxides are formed and occluded, which deteriorates the metal. (2) A mixture of metals heated much beyond the fusing-point tends, upon cooling, to separate into definite compounds, mixtures, and pure metals, and to congeal according to the fusing point of each; thereby forming a very non-homogeneous mass. The student should be interested in the prevention rather than the cure for this undesirable condition, and exercise care in heating metals. A metal or an alloy of metals should be heated only to the desired fluidity, so as to be in the melted state as short a time as possible. As it requires considerable time for a mass of metal to liquefy, and the different portions will have absorbed different amounts of heat, and the liquefied metal is rapidly absorbing more heat, it should be apparent, when the mass is one-half or three-fourths melted, that it has absorbed enough heat for liquefaction and should be removed from the fire. The pot having been removed from the fire, the metal is stirred with a stick of wood until the last portion of metal is liquefied. Should the metal be too viscid, it should be returned to the fire and stirred for a moment, when it will be ready for pouring.

Bismuth Compound.—Bismuth forms some wonderful alloys. They are much used in the dental laboratory. It constitutes about one-half the weight of the very low-fusing alloys. It and antimony are the only metals that expand on cooling. Hodgen states that bismuth expands $\frac{1}{32}$ of its volume. Combined with lead, tin, and cadmium, it forms alloys all of which melt below the most fusible component and a combination may be made to fuse as low as 140° F., while its most fusible component fuses at 442° F., and its least at 617° F.

Thus the three principal substances for dies may be summed up as: Zinc, fuses at 773° F., shrinks the most of any metal on cooling, hardest, and brittle; Babbitt metal (Haskell), fuses at 500° F., non-shrinking, neither as hard nor brittle as zinc; bismuth alloy, melts below boiling water, non-shrinking, and is less hard and more brittle than zinc.

Counter-dies.—A suitable counter-die must be prepared for the die. It is desirable that the counter-die shall be of a softer and more fusible material than the die. Softness is required that the compression produced in swaging shall take place in the counter and not in the die; fusibility, so that the counter may be readily formed over the die. Lead fusing at 617° F. is an excellent counter for zinc. Four or five parts of lead and one of tin fuses at about the same temperature as Babbitt metal (Haskell), and with care in handling forms a desirable counter-die. A counter-die for the bismuth compound alloy may be formed of the same material by first "smoking" the die, or coating with whiting wet with alcohol, and careful pouring. Modelling compound serves well as a counter, or the die may be driven into the end of a block of soft pine and it used as a counter. In the swaging machines various substances are used as a counter, for the bismuth alloy dies, as shot, cornmeal, sand, tallow, paraffin, or rubber.

Pouring the Die.—A suitable mold having been obtained in the sand, the melted metal is poured in until the mold is full, when, if the Bailey or Lewis flask is being used, the top section is placed and the pouring continued until the desired thickness of die is obtained.

The casting or die should stand until it is nearly cold before removing from the sand mold, as the metal while hot is very brittle and easily broken or defaced.

Making the Counter-die.—The die is placed upon the molding block, and sand built about it so as to cover all but the face; that is, the fac-simile portion of the mouth. The sand is built out at nearly right angles to the die for two inches. A molding ring is placed about the imbedded die and pressed slightly into the sand. Sand is embanked about the encasing ring to the height of one-half inch. The

counter-die metal is placed in a clean melting ladle or pot, and when half-melted removed from the fire and stirred until in a viscous or "mush-like" state, when it is poured or rather dumped upon the die. There should be about twice the quantity of counter-die metal melted as needed, because, being in a semifluid state, it cannot all be poured nor placed as accurately as if melted into a more fluid state. However, the excessive quantity, viscosity, and dumping will produce a perfect counter-die without danger of fusing the die. If the counter-die metal is liquefied and poured in a small stream upon the die, there is much danger that a portion of the surface of the die will be melted and the die and counter spoiled; and a portion of the metal so contaminated that it should not be used again for either a die or a counter. Therefore watchfulness while melting the metal and pouring while the metal is in a viscoid state will save time, metal, and vexation.

The die and counter-die should be cleaned of sand and examined for and relieved of any excrescences on their swaging surfaces. These surfaces are oiled as a preventive against any of the base metal adhering to the metal being swaged.

Swaging Gold Plate.—A suitable pattern for cutting the gold plate to size should be made. This pattern may be made of any thin pliable metal, as tinfoil or leadfoil. Tea-lead or tinfoil of about No. 20 serves well. The supply houses carry tinfoil in rolls designed for this use. A piece of pattern foil is placed upon the die and nicely conformed to its surface by pressure of the fingers and thumbs; it is removed and trimmed to the outline of the desired base-plate. The pattern base-plate is then placed upon a flat surface and pressed, but not rubbed, to flatness.

Gold plate of a suitable composition, carat, and guage is selected for the work in hand, the pattern is placed upon it, and its outline traced with a sharp-pointed instrument. The plate is then cut to the outline of the pattern with the plate shears. It is expedient for the inexperienced workman to cut the gold ⅛ of an inch larger than the pattern as an offset to inaccurate manipulation. The excess gold will be trimmed away after swaging and saved as scrap. While it is not

essential, it is advisable to cut the gold so that the fiber (crystals elongated by rolling) shall be across the denture.

The gold, having been cut to pattern, is annealed by heating to a cherry-red heat and cooling in water. It is well to reanneal the metal two to four times during the swaging process. After the metal has been upon the die it should be wiped to remove the oil and any adhering base metal that may be upon its surface before heating.

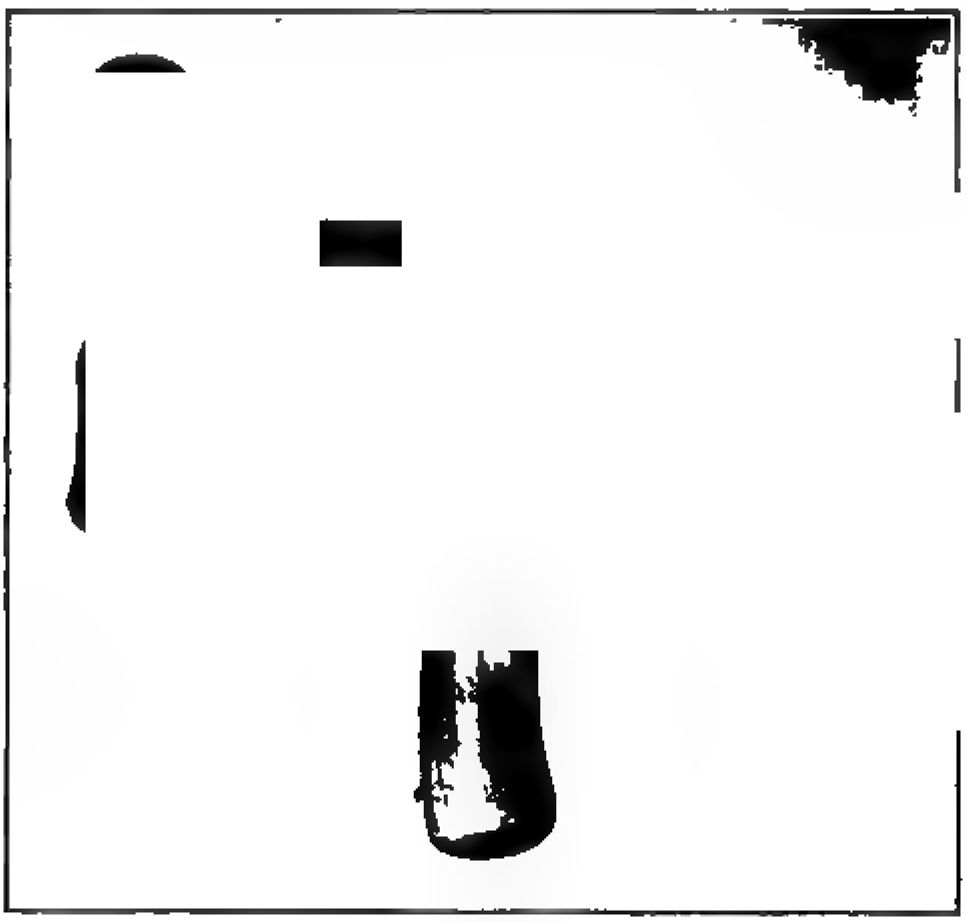

FIG. 282

The gold is conformed to the die with a horn mallet or one tipped with rubber (Fig. 282). For a full upper base-plate the conforming is begun at the center and extended in concentric rings outward. Care must be exercised at all times not to permit the gold to "buckle," that is, fold upon itself. Should a fold begin to form, it must be straightened out with pliers, annealed, and then malleted from the inner end outward. The plate should be well conformed to the

vault before any attempt is made to carry it beyond the crest of the alveolar ridge. In fact, it is well to have a half-counter-die (one made to cover the vault portion of the die only) and swage the vault portion before endeavoring to adapt the plate to the labial and buccal surfaces. The swaging is done with a heavy swaging hammer. A few dead blows should be used. The horn mallet is used with a light elastic blow, thereby marring the gold the least, whereas the swaging hammer is used with a dead pushing blow, thereby conforming without a backward spring, and with less hardening of the gold. In swaging difficult cases, that is, high vaults and heavy undercut ridges, it is well to clamp the plate and half-counter to the die with a C clamp (Fig. 283) while carrying the labial and buccal flange to place with the horn mallet. (This illustration shows a full lower base-plate.) For this part of the conforming a horn mallet with the small end filed to a blunt edge is preferable. Should the die be of the V-shape type the conforming may be more easily done by slitting the labial flange in the median line nearly to the crest of the ridge. The edges are permitted to overlap, and later are soldered. The base-plate being well conformed with the horn mallet, it is wiped of oil and base metal. As the plate must be annealed before the heavy swaging, it should be thoroughly inspected for evidences of adhering base metal from the die. Should any be detected that cannot be wiped away, it must be "pickled." The pickling is done by boiling in a solution of nine parts of water and one of sulphuric acid, in a copper acid pan. (In forming the pickle pour the acid, a little at a time, into the water. An explosion is liable to occur if the water is poured into the acid.) The base-plate having been well conformed with the mallet, it is placed in the oiled counter-die and struck a heavy, dead blow. It is then removed from the counter-die and inspected. If a buckle is forming, it should be corrected with the pliers and mallet, then returned to the counter-die and struck one dead blow and again removed and inspected. When the buckling tendency ceases it is thoroughly swaged.

It should be apparent to the student that a metal base-plate conformed and swaged over one die cannot accurately

fit the mouth for the reason that the force of all the blows struck upon the base-plate must be received upon the high points (rugæ and ridges) of the die; therefore the elevated portions of the die are compressed or "battered down." This condition can only be offset by annealing and swaging in a well-oiled second die and counter-die.

Fig. 283

When molding, two dies and counters should be formed, the better die and its counter to be reserved for the final swaging. If a very stiff base-plate material (as clasp metal) is being swaged, three or more dies and counters will be required.

Swaging Full Lower Base-plates.—The gold cut to pattern is annealed and grooved with the plate benders (Fig. 284), then conformed to the oiled die, beginning upon the lingual side of the ridge. When the base-plate has been malleted

for some time it may seem quite recalcitrant, and it should then be cleaned, annealed, and swaged one stroke in the counter, which will much aid the conforming with the mallet. In a high-ridged case a half-counter-die, covering the lingual surface only, will be useful (Fig. 283). The swaging is accomplished in the same manner as for the upper.

Fig. 284 Fig. 285

Swaging Partial Cases.—Fig. 285 shows a properly shaped model. The teeth stumps should be about $\frac{1}{32}$ to $\frac{1}{16}$ of an inch long, just enough to give and keep a clear outline of the teeth, about which the base-plate is fitted by swaging, nipping with the plate nippers (Fig. 286), and filing with a rat-tail or half-round metal file (Fig. 287).

The counter-die for partial cases should extend but little farther than the face of the die. Many operators imbed the die for both partial and full cases in the counter. This practice is worse than useless, because it is a trouble maker.

In forming the counter-die, all portions of the die not desired to be covered with the counter are imbedded in the molding sand. For half-counters the sand is built flush with or a little higher than the crest of the alveolar ridge, when a small molding ring is set in place and the counter-die metal poured into it.

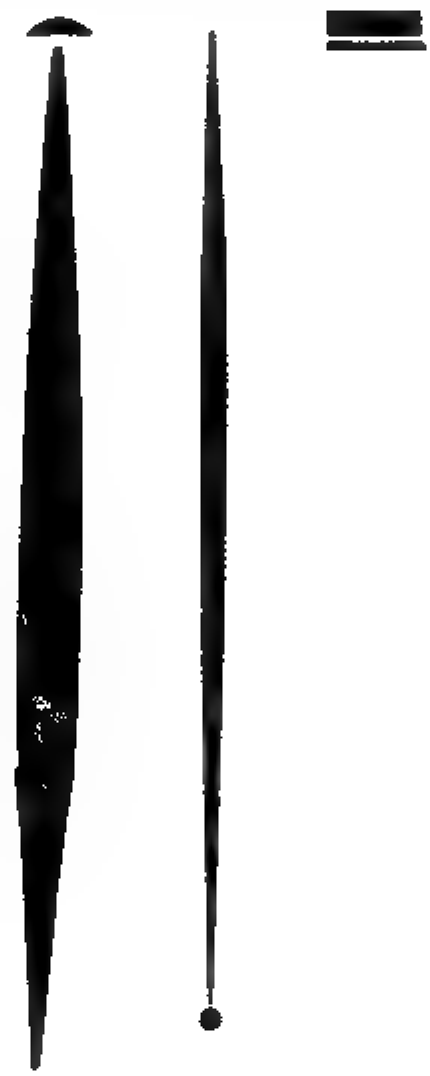

Fig. 286 Fig. 287

Doublers.—A doubler is a piece of metal fitted and soldered to the lingual surface of the base-plate to give additional strength and rigidity. These are specially required for partial cases. The doubler is usually formed of the same carat and gauge gold as the base-plate, although it may be formed of a more rigid alloy than that of which the base-plate is being formed, especially if a very high carat gold is used.

The doubler should be placed so as to receive the greatest strain that is placed upon base-plate; and to interfere with the tongue and speech as little as possible. The doubler may cover but a small portion of the base-plate or it may cover nearly the whole surface. It should be at least enough smaller than the base-plate to form a ledge upon which the solder is placed while soldering, and thereby forming a less noticeable joint.

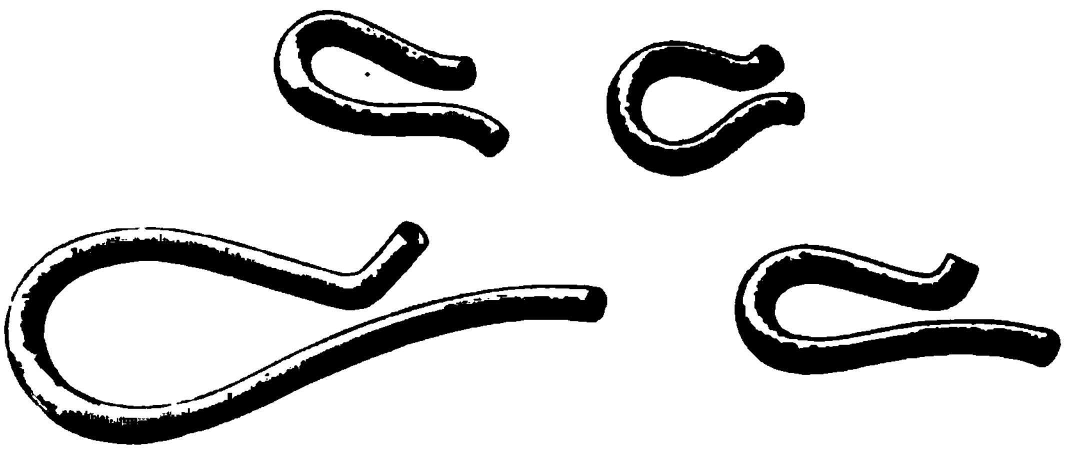

FIG. 288

Forming the Doubler.—A pattern is formed by pressing with the fingers a piece of pattern tin over the base-plate, and trimming to the desired form. The outline of the pattern is traced upon the sheet of metal to be used, then cut with the plate shears. The doubler is conformed by the mallet to the first die and swaged. It is then cleansed, annealed, placed upon the base-plate over the second die, and swaged. The edge is then filed to a bevel with the bevel on the outside of the doubler. This bevelling is to aid in the finishing, as the joint between the doubler and base-plate should be as nearly imperceptible as possible. The base-plate and doubler having been cleansed by pickling, the under surface of the doubler is smeared with a fine ground or liquid flux, clamped to the base-plate with wire clamps (Fig. 288) and soldered.

TECHNIC OF GOLD SOLDERING.

The necessary equipment for soldering gold is not large, but should be well chosen and their properties and use well understood. The necessary equipment consists of a good

investment compound, holders or supports for the work, flux, and a blowpipe.

Investment Compound.—There are a number of good investment compounds on the market. One made after the formula given on page 404 will meet every requirement. The investment should withstand the heat to which it will be subjected without fusing or cracking, and it should conduct heat readily. Unfortunately the bond (plaster of Paris) that is used in the investment compounds fuses at a low temperature (1100° F., Price), shrinks badly, and is a poor conductor of heat. Therefore only enough plaster of Paris should be used to give binding strength. The compound should have as few basic ingredients as possible, because it is a well-known metallurgical fact that two or more high-fusing basic substances may at a moderately low temperature form low-fusing compounds. Another factor to be taken into account in selecting an investment is that a material in a fine state of subdivision is more fusible than in a coarse.

Holders.—Holders are of two types, as blocks composed of charcoal, asbestos, or magnesia; and appliances serving the double purpose of holder and heater.

The charcoal block is chemically treated so that it burns only while in contact with a flame, therefore is safe to use in the laboratory. This is not true of a block of ordinary charcoal. The charcoal block is the best made for certain purposes, as it adds to the heat of the blowpipe flame and aids in deoxidizing metals. Its disadvantages are that it is black, brittle (both overcome by encasing), and is rapidly consumed. It is not suitable as a support for metals to be oxidized, nor working platinum. The asbestos blocks are cleanly, durable, and fire-proof, but otherwise nothing to commend them. The magnesia blocks are compact, cleanly to handle, quite durable, and so soft that some forms of work may be imbedded in its surface and thus be better supported.

Figs. 289 and 290 show two combined supports and heating appliances.

Flux.—Term derived from *fluo, fluxus*, to flow, and is applied in metallurgy to those substances that cleanse and aid

Fig. 289

Fig. 290

the flow of metals. In hard soldering (solder that requires a red or higher heat to melt) the alkali salts (preferably sodium borate (borax)) are used to cleanse the surface to be soldered by absorbing the oxides and preventing oxidation and making fluid the solder. For soft soldering (solder that requires less than red heat) zinc chloride and organic substances, as stearic acid, rosin, etc., are used.

Blowpipe.—The blowpipe is an instrument of simple and complex construction, for directing, increasing the heat, and concentrating the flame in metallurgical work.

The mouth blowpipe is of the simple type, and consists of a tapered tube either straight or bent, and is operated with the mouth by forming a bellows of the cheeks. This is an excellent instrument for light, quick service. However, it is questionable if it is profitable for the student to spend his time in mastering its technic, especially for large cases, when there are so many excellent mechanical devices for doing this work.

The mechanical blowpipe is more or less complex. There are many forms of this instrument designed to develop certain features for its use. As these various forms are described in all the reference books on prosthesis, one only will here be shown as an illustration.

The "Automaton" (Fig. 290) is designed to be and is to an extent automatic. Gas is admitted to the pipe by the anterior tube and air by the posterior tube. The pipe is equipped with a sliding arrangement of its barrel, which automatically regulates the quantity of gas and air, provided the supply of gas and air are under suitable pressure.

The air blast is furnished either by a foot bellows, a compressed-air tank, or power air pump. A very ingenius and efficient air pump known as the "Vernon Rotary Compressor" has recently been put upon the market by the Lee S. Smith & Son Company. It is only 3 inches high, 1½ inches thick, and weighs two and one-half pounds. It is designed to be coupled to the electric lathe or any small power in the office. Fig. 291 shows the complete machine and Fig. 292 its internal construction.

Use of the Blowpipe.—On page 244 the Bunsen burner is described as a tube with an opening near the bottom for the admission of air to the gas by natural draft. In the

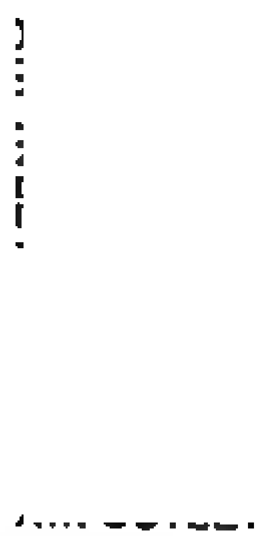

Fig. 291

blowpipe the air is forced into the flame, which gives a greater range of possibilities. The object of the flame is

Fig. 292

to produce heat. Heat is a result of chemical action manifested in the oxidation of the carbon and hydrogen of the fuel. It is obvious that oxidation can be controlled, hence

the degree of heat and its usefulness. Therefore the object of the blowpipe is to create, direct, and control heat. The blast of air increases the amount of oxygen, the rapidity of oxidation, and heat up to a certain point, after which an increasing blast cools the combining gases until the temperature is reduced below the ignition point and the flame is extinguished, "blown out." It is impossible for the operator to tell when he has reached exactly the highest degree of heat and the flame is beginning to cool. However, he knows that a yellow tinge indicates carbon imperfectly combined with oxygen, and that the blue color in the outer two-thirds of the length of the flame indicates perfect combustion and that the point of highest temperature is being approached or passed. (The flame is always blue at its base, but this is because the carbon has not yet reached the yellow stage.) Therefore a yellow flame indicates a comparatively low degree of heat, and that as the blast is increased the temperature increases with the disappearing yellow color; that the succeeding blue color indicates perfect combustion, and that the temperature is increasing until the highest degree is attained, and then an increasing blast chills the flame until it is below the ignition point and extinct.

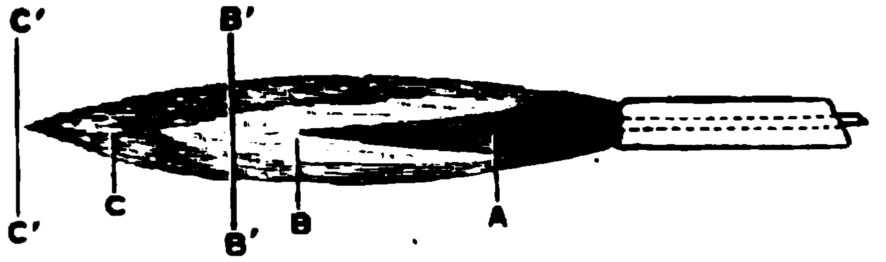

FIG. 293

The blowpipe flame, like the Bunsen flame, has three zones: the inner or gaseous zone, the middle or combustion zone, known as the reducing flame, and the outer mantle or oxidizing flame. The diagram shown in Fig. 293 illustrates the three zones, *A*, *B*, *C*. Work to be heated and soldered should be placed in the reducing flame at *B′ B′*, where it will be heated, cleansed of any oxides, and the solder nicely flowed; but if the work is placed at *C′ C′* or advanced to *C* the work will be made dirty by oxidation and be endangered

by burning. The soldering can be done at this portion of the flame only by the use of an excessive amount of flux.

The flame is used either in the form of a brush or a needle. These are easily produced with a mouth blowpipe by having the nozzle outside of the flame for the brush form and in for the needle. The same results are obtained with the automaton by using a large flow of gas and light air-pressure for the brush and a small flow of gas and a moderately heavy air-pressure for the needle flame.

SOLDERING ATTACHMENTS TO THE GOLD BASE-PLATE.

There are three classes of attachments, known as strengtheners, finishers, and retainers.

The strengthener may be in the form of a doubler or wire. The wire strengthener may serve as a finisher, while the finisher is always a strengthener.

Soldering Doublers.—The base-plate and doubler having been pickled and thoroughly cleaned, the doubler is smeared on the under surface with a fine-ground cream or paste of borax. (If desired the proprietary fluxes in the supply houses may be used. They are composed principally of borax.) The base-plate and doubler are firmly pressed together and clamped with wire clamps. (See Fig. 288. These clamps are formed of soft-iron wire, guage 15.) Solder, two carats lower than the base-plate, is cut in pieces $\frac{1}{8}$ by $\frac{1}{8}$ or $\frac{1}{8}$ by $\frac{1}{4}$ of an inch, fluxed, and placed upon the base-plate at the edge of the doubler for one-half of its circumference. The work is supported upon a soldering block, preferably of charcoal, with the solder-decked edge elevated. The yellow-tinged brush flame is applied to the base-plate and doubler with the greater heat at the farther side of the doubler from the solder. This will cause the solder to flow between the base-plate and doubler and completely fill the space between them. The solder flows between the two plates of metal in place of running away, because of three physical laws, as follows: (1) Solder always flows to the hottest point. (2) Capillary attraction. (3) Gravitation. Should every por-

tion of the joint not be filled at the first flush, more solder should be added, at the deficient point, and flowed. No attempt should be made to remelt the first flush of solder. The case is pickled to remove the flux and reswaged in the last die and counter by two or three dead blows of the swaging hammer.

Soldering Finishers.—A gold base-plate that is to have the teeth attached with vulcanite should have a finisher provided for the joining. However, the finisher is often omitted as a means of saving labor and expense, but always at the expense of strength and perfection. The finisher may be in form, either thin plate or wire. Upon the buccal and labial surfaces the thin plate finisher may be formed either by turning the edge or soldering on a swaged piece of plate. Finishing the lingual surface of the joining with thin plate can only be accomplished by swaging and soldering an extra piece of metal. A wire soldered about the periphery of the joining is the neatest, strongest, and best way of forming a finisher.

Turning the Edge of Base-plate.—If a turned edge of the labial and buccal surfaces of the base-plate is desired, the impression is prepared by making the required outline of the edge of the base-plate and carving away, at right angle to the median plane of the impression, the border of the impression to the indicated outline. This will result in the forming of a ledge upon the die that will turn the edge of the plate at right angle. The balance of the turning is done with pliers.

Swaging and Soldering the Labial and Buccal Finishers.—For this purpose wax occlusion and contour models are obtained, the case placed on the antagonizor, teeth mounted, gum portion restored either with porcelain sections or wax; when an impression is obtained of the surface for which the finisher is to be formed, the model, die, and counter formed, and the finisher swaged. The finisher will be in two sections, each extending from the median line. The teeth and wax are removed from the base-plate in a mass by warming the under surface of the base-plate. The finisher, boraxed, is clamped to the base-plate with wire clamps, solder placed in the crevice and drawn outward by the blowpipe flame.

The same procedure is required for forming the lingual thin plate finisher. However, the work is carried on at the same time (not after) as the buccal and labial finisher.

This method necessitates much labor and mechanical skill, and when completed is neither as strong nor cleanly as the wire finisher.

Fig. 294

Wire Finisher.—This finisher is formed by using an 18 or possibly a 16 B. & S. gauge, 20-k, gold wire, and forming it to the base-plate. The conforming is done by bending the annealed wire with the fingers and pliers so as to approximate the periphery of the base-plate. Begin at either tuberosity and conform the wire for one inch, attach with wire clamps placed at both ends of the conformed portion, place a small portion (size of the head of pin) of boraxed

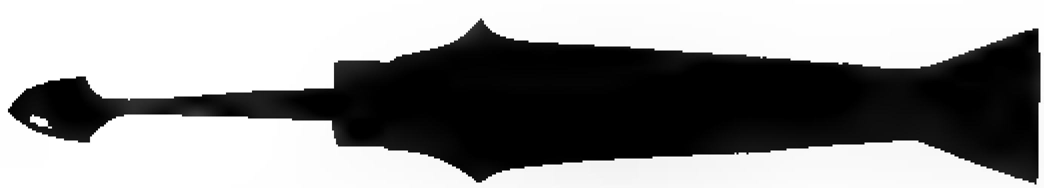

Fig. 295

solder at some point of contact, and melt. Continue the conforming and tacking an inch at a time until the wire is carried the entire length of the joining of the base-plate, and vulcanite. The base-plate is placed upon the die and the tacked wire closely adjusted to the base-plate for its entire length. This may be done with a plate burnisher (Fig. 294 is the Prothero, and Fig. 295 is the Wilson plate burnisher), or a small copper riveting hammer may be used. The base-

plate is removed from the die and inspected for base metal. The crevice is smeared with flux and a generous quantity of solder placed along the upper edge (as supported on the block) of the wire for its entire length; it is supported on a soldering block and the yellow-tinted blowpipe flame applied carefully over the whole surface of the base-plate until the flux is dry, when the flame is placed at either tuberosity and concentrated at the lower edge of the wire, thereby fusing and drawing into place the solder, advancing piece by piece until all is fused.

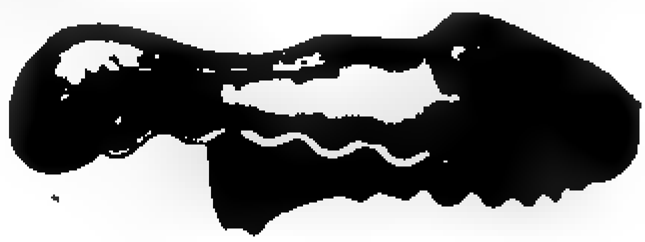

FIG. 296

FIG. 297

FIG. 298

Retainers.—Retainers are loops soldered to the base-plate, about which the vulcanite is attached. It is obvious that the

greatest efficiency of the retainers is at the periphery of the joining. They are formed of wire, or narrow strips of scrap gold plate, convoluted. The convoluted strip or wire is clamped to the base-plate and soldered. Figs. 296 and 297 show a gold base-plate, with the vulcanite removed, that was worn for some years. Figs. 298 and 299 show a completed denture.

Fig. 299

Warping in Soldering.—The base-plate is subject to warping by unequal expansion of the metal while soldering. This can hardly be avoided. Base-plates are often unnecessarily warped by clamping to the soldering block with a spring clamp. When all metal attachments have been made to the base-plate it is placed upon the die and inspected; if any rocking or springing appears as pressure is applied on different portions of the base-plate, it should be placed in a swaging machine, as the Parker shot swager, and reswaged.

The base-plate is now tried in the mouth, and if satisfactory, wax is built upon it for the occlusion and contour models; when the subsequent procedures are the same as for a vulcanite denture.

Soldered Gold Artificial Dentures.—Prior to the introduction of vulcanite the teeth were soldered to the base-plate. This necessarily was a very unsanitary appliance. There

is no logical or practical reason why such a denture should be inserted at this stage of the development of dental prosthetics. However, there are a few cases in which a modified form of the method may be of the greatest service. Fig.

Fig. 300

300 shows the lingual surface of such a partial denture. The patient for whom this appliance was constructed had a very long upper lip and the lower teeth shut very close to the upper gum. Facings were backed with 26-gauge clasp gold, backings closely fitted to the base-plate, invested, and soldered. The labial gum restoration was made with vulcanite. Fig. 301 shows the labial aspect of the same case.

Fig. 301

There are some partial cases which require no gum restoration, that because of the close shut will require a metal-back facing soldered to the gold base-plate; or if the base-plate is to be vulcanite a metal tang of clasp metal is soldered

to the backing of the facing and extended backward into the vulcanite base-plate. Fig. 302 shows such a facing backed and tanged. Bicuspids for very close shut cases may be provided with a porcelain-faced gold dummy (such as is used in bridge-work) soldered to the base-plate. For molars the facing may be better omitted.

Fig. 302

Soldering Porcelain to Metal Base-plate.—This work requires that a stiff rigid plate of metal be closely fitted and attached to the facing with solder; or the facing may be backed with either 35-gauge pure gold or platinum, invested and contoured with 22-k solder. The facings, however backed, are adjusted to the base-plate and soldered.

Fig. 303

Fitting the Backings.—Tinfoil patterns are made of the backings and traced upon the gold to be used. It is well, as a precaution against inaccurate workmanship, to punch the pinholes before cutting the backing from the stock piece. The English double punch (Fig. 303) may be used and punch both holes at the same time, or the single punch (Fig. 304) may be used and punch the holes separately.

If the double punch is used the tooth to be backed will adjust the punch, while with the single punch the plate must be marked for the punch. This may be done by slightly smearing the metal with wax and pressing the pins of the tooth into it, or tinfoil punctured by the pins of the tooth may be laid upon the metal as a guide to punching. The backing is conformed to the facing as closely as possible by bending. The edges are filed to a bevel and burnished to the facing. The facing and its backing are temporarily held together by turning down a shaving from the side of the pins made by a cut with a sharp knife or chisel.

FIG. 304

Investing and Heating.—The teeth backed and luted to the base-plate are removed from the plaster cast, invested with investment compound to a thickness of $\frac{1}{4}$ to $\frac{1}{3}$ inch. The investment is thoroughly dried, and while warm a small amount of flux, rubbed to a cream or mixed with vaselin is applied to the joints and pieces of fluxed solder placed upon the joint, also a small piece rested upon each pin so as to unite the pin and backing. The invested case is placed upon a combined supporter and heater (Fig. 290), and gradu-

ally heated until it has attained a dull red heat. The porcelain must be heated up through the investment rather than through the metal backing. In other words, the porcelain must expand in advance of the metal pins to avoid cracking. The work having been heated to a dull red state is ready for the blowpipe. The yellow-tinted brush flame is played over the investment and gradually brought over upon the metal, and the brush flame continued until the solder begins to melt, when each piece of solder is touched consecutively with the blue needle flame and thoroughly flowed. Should any portion of the work require a large amount of solder after the first tacking, it is best done by feeding into the flame, held at the point to be filled with solder, a long strip of fluxed solder held in clamped tweezers. Care must be exercised not to hold the flame at one point long enough to melt the work. This is accomplished by interruping the flame contact.

Cooling the Investment.—The fire is withdrawn and the case permitted to stand until cold. No precaution is required, except to protect from drafts of air, as too rapid radiation of heat might craze the porcelain. The investment compound is a poor radiator of heat, therefore retains the heat and permits the metal to cool in advance of the porcelain. The cracking of porcelain in soldering is largely due to expanding the metal pins in advance of the porcelain in heating up and cooling the porcelain in advance of the pins in the cooling-off process. Hence the principal time of danger of cracking is while heating up.

Partial Upper Dentures.—The base-plate is designed in outline to meet the requirements of the case. Modern thought requires as little of the vault to be covered with the base-plate as is consistent with strength and rigidity. Fig. 305 shows a partial gold base-plate fitted about all of the remaining teeth. Figs. 306 and 307 show a band base-plate with as little surface covered as is consistent with stability. The band should extend across and in proximity to the highest portion of the vault. Fig. 308 consists of a cast saddle with lugs. The clasps and swaged band are soldered to it. Fig. 309 shows the completed denture.

Partial gold base-plates may be constructed by either the swaged or cast method. However, as has been stated, the quality of adaptation is the only factor of superiority

Fig. 305

Fig. 306

Fig. 307

of the cast over the swaged base-plate; and it is questionable if this closeness of adaptation is desirable; if contact with a

Fig. 308

smooth surface is not more acceptable to the contiguous tissues. As contact is almost a negligible factor in the retention of partial base-plates, the contact over the vault portion of the mouth may be ignored; except that sufficient

Fig. 309

contact must be had to prevent the sound waves of vocalization passing between it and the roof of the mouth.

Swaging.—The model, die and counter, swaging and reinforcement have been considered. Clasps as retainers, their form, location, and construction are discussed in Chapter VII, but adjusting the clasp to the base-plate will require attention.

The partial base-plate with all of its attachments soldered, save clasps, is tried upon the die, and if found out of shape it is reswaged in the swager. The base-plate is then pickled and cleansed and adjusted to the mouth. Should its weight be too great for its retention by contact, the maxillary surface is moistened and sprinkled with powdered gum tragacanth and held in place for a moment until adhesion is established. A plaster impression is taken sufficient to cover the portions of the teeth to be clasped and the contiguous base-plate. Should the base-plate not leave the mouth with the impression, it is removed and replaced in the impression. Another plaster impression is taken, necessarily of the teeth to be clasped only. This impression may be of the teeth individually or collectively. The impression containing the base-plate is varnished and carefully filled with investment compound. The impression of the teeth only is varnished and filled with plaster or, preferably, Spence plaster compound. Some prefer filling this impression with bismuth alloy, but nothing is to be gained over the Spence compound save time, and there is danger of contaminating the clasp metal with the base metal of the bismuth alloy. The Spence compound should stand about an hour before taking from the impression, and then another hour or more to harden. The clasps are formed over the Spence compound casts, as instructed in Chapter VII, and adjusted upon the investment compound cast containing the base-plate. Contact must be had between the clasp and base-plate either by proximity or another piece of metal called a standard. Sometimes two standards are required (see Chapter VII). If the base-plate is securely caught in the investment compound cast and the clasps are securely held by their inherent elasticity, no further investment will be required; but if the parts to be soldered are not securely held, the cast should be saturated with water and invested with the spaces for

soldering as wide open as possible. The case is well dried, the joints supplied with flux and solder, and heated; rapidly if desired, as there are no porcelains to be considered. If the clasp and base-plate are to be connected by a standard the upper end should first be soldered, as otherwise the contraction of the solder about the lower end of the standard is liable to pull it away from the clasp. The soldering completed, there being no porcelains attached, the case may be rapidly cooled by placing in water. The metal is then pickled, when it is ready for the vulcanite superstructure. The base-plate without porcelains may be rapidly pickled by heating nearly to redness and quenching in the pickle bath.

CASTING METHOD.

Pure gold is not suitable for casting for any part of denture construction, but must necessarily be made harder, more rigid, and for certain uses, as elastic as possible. The metals suitable for alloying the gold for casting are—silver, copper, platinum and palladium. Silver is used chiefly to modify the color; copper is used to give hardness and elasticity, it reduces the fusing point of the gold markedly and deepens the color; platinum is used to increase the hardness, elasticity and raise the fusing point; palladium is used to add the same properties as platinum and is better than a high percentage of platinum as it unites more uniformly with the gold and weight for weight raises the fusing point of the alloy more than platinum; however, palladium destroys the gold color, reducing the mass to the color of platinum. The high fusing and elastic gold alloys are restricted, therefore, to bands, bars and clasps.

The Ney-OrO golds made from the formulæ of Mr. Louis J. Weinstein are undoubtedly the most uniform and scientific casting golds upon the market. Further than this their formulæ are published; therefore, they are ethical and professional material. The dentist knows what he is using and can use the Ney-OrO golds intelligently, which cannot be said of any make of gold that does not publish its formulæ. These golds may be melted with the gas and air blow-pipe,

but are more suitable for the gas and oxygen or nitrous oxid blow-pipe. Care must be used to thoroughly melt, but not to overheat or burn the gold. This implies that a sufficient illuminating gas flame is used and not an excess of oxygen forced into it, but enough to accomplish the desired result.

The Ney-OrO casting golds that will meet every requirement are the following.

	"C" Per cent.	"B" Per cent.	"E" Per cent.
Gold	80.5	80.0	64.0
Platinum	6.5	9.5	11.0
Palladium	2.0	2.5	16.5
Silver	2.0	1.0	1.5
Copper	9.0	7.0	7.0
Total	100.	100.	100.
Fusing point	1800° F.	1975° F.	2100° F.

Ney-OrO "C" is suitable for cast full dentures and saddles that are to be reinforced. It should be melted with the gas and air blow-pipe only. Ney-OrO "B" is designed for any full or partial denture requiring greater rigidity with less bulk than can be attained with "C." This gold can be properly fused with the gas and air blow-pipe provided the operator is expert and the mass of metal is not too great. Ney-OrO "E" is suitable for clasps, bars, bands and any part where the greatest rigidity is required. This gold may be melted in small quantity with the gas and air blow-pipe, but it can be better manipulated with the gas and oxygen or nitrous-oxide blow pipe, when any quantity desired can be properly fused.

Investment Compounds for Gold Castings.—It is the opinion of the writer that the liquid graphite investment is better adapted to small castings as clasps and small saddles, but that large saddles and full dentures can be better manipulated with the silica compounds, because of their greater strength and porosity. However, either class of material may be used universally. It is the opinion of the writer that better results are obtained by using either one alone than by using both in the same flask.

General Suggestions for Gold Castings.—There are two methods for making gold castings, known as the Direct and

the Indirect. The direct method consists of forming the wax pattern upon the cast and investing the two together; the indirect method consists of forming the pattern as for the direct method, but removing it from the original cast for investment and casting. The direct method necessitates that the cast shall be formed of the investment compound, while for the indirect method the cast should be formed of hard plaster compound. The best results seem to be obtained from "green" molds, that is, where the investments have not been permitted to dry out by long standing; therefore, the indirect method gives smoother and better results than the direct. However, if the original cast is used and it has become thoroughly dry then it should be thoroughly soaked in water before adding more investment, also before heating up if a flasked case has stood for a day or two. This suggestion is thoroughly empirical, for the writer is not satisfied with any explanation he can offer.

If the casting table of a pressure machine is not recessed a shallow recess should be cut in the investment to aid in the escape of gases while casting.

Too thin casting wax should not be used, thereby avoiding imperfect or weak castings. Use 16 gauge (B & S) sprues and a sufficient number to fill every part of the mold promptly.

Use clean metal for each melting. If the metal has been previously used clean it with reducing flux and acid.

Heating the Flask.—All cases should be warmed slowly so that the wax model may be absorbed by the investment, if a small one, and partially absorbed if a large one when the flask can be inverted and the excess of wax permitted to run out of the sprue holes. The heat is gradually increased until the mold is thoroughly dry of wax and moisture. The mold is now known as a cold mold although it may be a few hundred degrees hot. The cold mold is desirable for clasps and very small saddles, but for large castings and where the molten metal must flow some distance the mold must be hot, red hot. The smallest-sized casting flasks may be sufficiently heated in a Maves' Furnace (Fig. 310) in thirty-five or forty minutes, but the next size flask will require fifteen to twenty minutes longer, while the large-sized flasks will require from

one to two hours in the open flame. Do not attempt large castings in a cold mold. The Maves' Furnace is suitable for the "cold mold" only.

FIG. 310

Pressure Required for Casting.—Very small castings will require 8 to 12 pounds' pressure, and medium to large castings will require 15 to 20 pounds' pressure.

The investment compound must not quite fill the top of the flask. There must be at least one-sixteenth of an inch of free flange to permit the flange bedding itself into the asbestos packing of the head of the casting machine. Sufficient force must be applied and sustained upon the closing lever to prevent escape of the compressed air. Necessarily the larger the perimeter of the flask the greater the pressure to make a tight joint between the flange and packing.

Making the Wax Model for Casting Gold.—For the direct method of casting the investment compound cast needs no

preparation; but for the indirect method the hard plaster cast should be slightly lubricated with sweet or sperm oil, or the surface may be sprinkled with soap-stone, which should be well rubbed in, and the excess brushed away. The cast may be slightly warmed, but not above 100° F. The casting wax may be sufficiently warmed by holding for a moment between the palms of the hands and adjusted to the judiciously warmed cast. Extra heat is best applied by warming the thumb or hand rather than by exposing the wax to direct heat. For the indirect method the wax must be perfectly molded to the cast and luted at a few points only. Portions

Fig. 311

of the surface may be doubled by the same careful warming and conforming of the added wax. Round wax attachments are more safely attached by luting with melted wax carried on a small spoon as the Number 1 Evans' wax carver. The wax sprue formers should be approximately 16 B & S gauge in size, the middle size round of the Mathews wax former. Often these feed sprues can be so attached that they will also form the cleats of the vulcanite attachments. Judgment must be used to place a sufficient number of sprues to quickly and perfectly fill the mold. A clasp will require one feed sprue, with possibly an auxiliary, as shown in Fig. 311. Saddles will need two or more and a full denture may need

eight or ten. These sprues must all have separate openings into the floor of the melting crucible. (See Fig. 312.) They must be so placed and sufficient metal used so that they are all covered with the molten metal until the mold is perfectly filled. Should a single one of these feed sprues be exposed to the compressed air the casting will be spoiled.

FIG. 312

Investing and Flasking.—The wax model is first invested and then flasked. If the direct casting method is to be used, the wax model is thoroughly luted to the cast, and then coated over with a thin mix of the investment compound, applied with an ox-hair brush, lapping it well upon the cast. As the investment begins to set it may be poured on from a spatula at those places needing special support, as the sprues and cleats. For the indirect method the wax model is luted only at two or three points, just enough to hold it in place, and then the outer surface invested the same as for the direct

method, only the investment must not lap upon the cast. When the investment has set sufficiently to have good rigidity the luting wax is freed with a sharp lance knife, when the partially invested wax model is carefully removed from the cast and the inner surface is then invested in the same manner as the outer surface, permitting the investment to well lap upon the outer investment, and then permitted to stand until the new investment is set enough to handle safely. The invested case is then flasked as shown in Fig. 312. Fig. 313 shows a full upper model denture formed ready for investing and flasking.

Fig. 313

The base is formed of either 28 or 30 gauge casting wax, palatal border is doubled, and the labial, buccal peripheral border and the lingual shoulder are traced with wax formed from the No. 1 (small) nozzle of the Mathews wax former

(Fig. 247). The eight sprues are formed by the No. 2 nozzle and the auxiliary sprues of the No. 1. The eight number 2's are curved and drawn upward so that when the crucible mold is formed the entrance to each sprue hole will be downward.

Fig. 314

Fig. 315

Partial Dentures.—Partial dentures are best cast in units and the units united by soldering. A unit is a clasp, saddle or a connecting bar or band. Two saddles can be joined with a bar by lap joints better than by butt joints. There is necessarily shrinkage in casting; however, this can be largely compensated by sectional castings, and lap joints. (See Fig. 314.)

Fig. 315 shows the five units—two clasp units—two saddle units and the connecting unit united with solder.

Swaging Cast Dentures.—The casting may be swaged, often with advantage. The Parker Shot Swager (Fig. 271), or a similar swager may be used. This method is especially adapted to full dentures. The hard plaster compound cast is centered and set in the base of the swager with a fresh mix of plaster, or with high heat modelling compound. The casting is then placed upon the hard plaster cast, and covered with light weight rubber dam, and a sufficient quantity, to nearly fill the swager, of low-heat modelling compound is quickly adjusted, the plunger adjusted and submitted to heavy pressure in a screw press; or, it may be struck one dead blow with a heavy sledge (16 pounds). Moderately stiff putty may be used in place of low heat modelling compound. A better way than striking with the sledge is by the English drop swage. This is a miniature pile driver. The drop swage has the advantage over the sledge in that it holds the base-plate under pressure until the molecules of metal become set from the vibration produced by the swaging force. Cast aluminum may be swaged in the same manner.

Amount of Gold to Use.—The same rule given for aluminum will serve for gold; therefore multiply the weight of wax by forty. However, for large gold castings multiplying by thirty will give a sufficiency.

The castings are finished by grinding, filing, buffing and burnishing. Ivory soap is a good lubricant for the burnisher of either steel or stone.

Casting Methods and Machines.—There are four physical principles usable in dental casting methods; namely, gravitation, centrifugence, vacuum and pressure.

The gravitation method is dependent upon a low fusing point and weight. It is suitable in dentistry for tin and its alloys only. The method is treated of in Chapter XII.

Centrifugence is matter revolving about a rotation center, its power is created by the velocity and weight of matter, and its force is exerted toward throwing the matter off at a tangent from the rotation center. The principle has the advantage of great simplicity, as an effectual machine may

be formed by a bucket swung at arms length; or gear wheels may be utilized to shorten the radius and increase the velocity. This principle is dangerous because of the possibility of accidentally throwing the molten metal out of the machine. This principle is elaborated in Chapter X; however, the Billmeyer method is not suitable for gold casting, because

Fig. 316

of the high specific gravity and fusing point of gold, a large enough feed sprue cannot be used. It is necessary that a feed sprue shall connect with all of the high points so that the molten metal enters directly to every portion of the mold. This is illustrated in Figs. 268 and 316.

THE HOLLENBACK UNIT.[1]

This machine is probably the best illustration of a casting unit, incorporating the centrifugal force and cold mold

Fig. 317

Fig. 318

principles, before the profession. It is a compact, simple and easily operated device. The oven is designed for drying out

[1] This machine is an invention of Dr. G. M. Hollenback and manufactured by the Occidental Manufacturing Co., of Los Angeles, Calif.

the investment for cold casting of inlays and clasps. The cold mold method is not suitable for castings larger than clasps and saddles that can be produced in the small-sized

Fig. 319

casting ring. The oven has a tray upon which 1 to 5 cases may be dried at once. The electrical units are placed upon each side of the tray and are regulated by a thermostat so that a temperature under 400° F. is constantly maintained

Fig. 320

for one hour and a half. In about one hour after the wax pattern is invested the flask is placed upon the oven tray with the sprue end downward. As the wax pattern melts the

excess water of the green investment washes out the wax, and does not permit of any appreciable absorption of the wax by the investment compound. When the investment is perfectly dried the flask may be set aside and the casting made at any convenient time. However, the casting should be made before the investment absorbs moisture from the atmosphere.

Fig. 321

The casting apparatus is operated by a spring and release lever, therefore is uniform and reliable in action. The crucible is made of fire clay and is easily replaceable. It is impossible for any of the molten metal to enter the mold before the spring is released; and the molten metal can be suitably fluxed without danger of the flux entering the mold. The parts of the casting portion of the unit are so placed that the least possible heat is applied to the mold. The result

is that a bright clean perfectly fitting casting is produced, after cleansing in hydrochloric acid.

The large flask is for saddles and the various sections of a partial denture that are too large for the small flask. The wax pattern is carbonized and burned out and the casting is made in the hot flask.

Fig. 322

Vacuum is exhaustion of air from an enclosed space, and its power is the weight of the column of external air compared with the degree of exhaustion of the confined air. Therefore, the vacuum machines are a modified form of the pressure machines. Its advantages are that the method permits application of heat while the force is acting, if desired, and it admits observation of the disappearing metal. Its disad-

vantages are that its power is limited (but enough for practical use), and its force is forward, very little lateral or backward; however, this disadvantage can be practically overcome by manipulation. This disadvantage and the method of overcoming it is nicely illustrated in the instructions given for the Laing-Elgin method (Fig. 318). Fig. 267 is the Elgin Vacuum Machine, it is very efficient and extensively used.

Pressure Principle.—This has the greatest range of application and power. The pressure may be created by compressed air or other gases, steam or explosions. The advantages of this principle are that the power is unlimited and may be continuous if desired, also it acts to force the molten metal in every direction, and holds it under pressure as long as desired. The disadvantages are that the heat must be removed, the compression tends to cool the metal, and the molten metal is out of sight. Fig. 319 shows the perfection with which molten metal is forced in every direction under direct pressure. The metal, Ney-OrO "B" was melted by a gas and air blow-pipe in a hot mold. It traveled downward over an inch and spirally upward about nine and one-half inches. The diameter of the casting is number 13 B & S gauge. It was cast with a Burns' Casting machine. Fig. 320 shows the Burns' Casting machine fitted with a compressed air guage; also equipped with a tank and pump for use where there is not a compressed air supply.

Fig. 321 is the Dental Mfg. Co.'s Compressed Air Casting Machine. It is equipped also with the tank and pump.

BAR, LOWER DENTURES.

Partial lower dentures may be made with a band of vulcanite (Fig. 334) on the lingual aspect of the remaining natural teeth; or with a band of reinforced gold (Fig. 322); or with a bar as shown in Fig. 325. The bar has the merit of being less cumbrous and interfering with the adjacent tissues the least of any method yet devised. The method is growing in popularity with both patient and practitioner.

Technic.—The saddles may be made of either swaged or cast gold. (There is probably no place where the cast base

is as applicable as for these cases.) In either case the bar should be made of clasp gold wire soldered to the saddles; after which the clasps should be formed and soldered to the saddles. As the bar with vulcanite saddles are the most commonly made, its technic will be sufficient for the method, as the slight modification required for the metal saddles will suggest itself to any workman's mind.

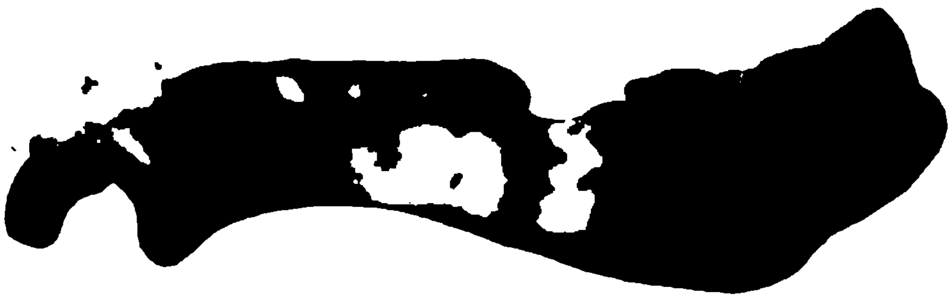

FIG. 323

Material.—No. 12 B. & S. gauged *clasp gold* wire is the material used. Should it be apparent that unusual strength will be required, No. 11 gauge wire may be substituted, or two wires of No. 15 or 16 gauge, soldered one above the other, will serve well the purpose. An elliptical wire No. 9 x 13, is better than either 12 or 11 round.

Single Wire Method.—A plaster impression is taken and a Spence compound cast obtained. (Care should be exercised not to deface this cast, as it is the only one required to complete the denture.) Retaining clasps are fitted to the teeth to be clasped. A line is marked upon the lingual aspect of the cast to indicate the position of the lower edge of the bar. The bar must be kept high enough not to interfere with the frenum lingua or other soft tissues of the floor of the mouth. A roll of soft wax is conformed to the cast so that its upper surface will form a ledge parallel with the line marked for the bar. This ledge of wax is for convenience in shaping and supporting the bar. A bar, sufficiently long to extend at least $\frac{1}{2}$ inch into each saddle, is annealed by heating to a dull cherry-red and quenching in water. This is bent with the fingers and a pair of pliers having one oval-faced beak. The bending is continued until the bar rests upon the edge of wax and is from $\frac{1}{32}$ to $\frac{1}{16}$ of an inch from the cast. If the wire is nearer the soft tissue than $\frac{1}{32}$

of an inch there is much danger that it will in time become a source of irritation. The bar and clasps are removed and the cast is painted with liquid silex above the wax ledge and for $\frac{1}{8}$ inch beyond the clasped teeth. The clasps are then

Fig. 324

replaced with just enough tension to hold them securely, and the bar set in place upon the ledge of wax. The clasps and bar are then luted together with a batter of quick-setting plaster, the plaster extending from one clasped tooth

Fig. 325

to the other. The plaster luting should rest upon the lingual aspect of the intervening teeth only to give body to the lute. When the luting plaster has become hard and strong, it is removed from the cast. It will hold the bar and probably

both clasps. However, should any one or all three of the pieces of metal be parted from the luting they are easily replaced and fastened with a little wax. Fig. 323 shows the luting plaster with the clasps waxed in place. The plaster luting is varnished with shellac and sandarac and covered with investment so as thoroughly to hold and support the

FIG. 326

FIG. 327

bar and clasps. Fig. 324 shows such an investment with the luting plaster cut away and the clasps and bar united with standards. Fig. 325 shows the same case removed from the investment and placed upon the Spence compound cast. The remainder of the work of construction is vulcanite work, and should need no further description.

Double Wire Method.—Fig. 326 shows the two wires of No. 16 gauge united with wax. They are removed and invested as shown in Fig. 327, soldered together with 18-k or 20-k solder. This bar is then luted with plaster to the clasps and soldered as previously described.

Fig. 328

Too Close Fitting Bar.—Dr. S. Marshall Weaver describes a method for bending back the bar when unfortunately it presses into the soft tissues. A little wax is melted upon the bar opposite the impingement. The denture is then invested in Spence compound, heavily covering all but the portion of wire opposite the wax or that portion impinging upon the soft tissues. When the Spence compound is thoroughly hard the bar is bent into the space formed by the wax, with a punch and mallet.

SOME PRACTICAL CASES.

A few practical cases will offer suggestions to the student for improvising gold attachments for special cases.

Fig. 328 shows a cast with clasps attached. Fig. 329 shows the same case waxed ready for flasking.

Fig. 330 shows a partial upper vulcanite to supply the teeth distal to the cuspid on one side of the mouth, with all the remaining upper teeth closely articulated (knuckled). It was necessary to clasp the cuspid, carrying it slightly under the gum, as that was the only way of getting a grip on the

tooth; besides, the natural gum was exposed when laughing, necessitating the clasp being accurately fitted and appearing as a cervical filling. The attachment for the other side of the mouth consisted of a crib formed by fitting a piece of clasp

Fig. 329

Fig. 330

gold plate upon both the buccal and lingual surfaces of the first and second molars, and these joined with a U-shaped staple of half-round 11-gauge clasp gold wire resting in the groove between the molars.

Fig. 331

Fig. 332

Fig. 331 is a bar lower for the same mouth. The teeth are missing from the cuspid backward on the opposite side of the mouth from the upper shown above. This case required a clasp upon the cuspid. Fortunately there was a space between the second bicuspid and molar, so the crib was formed with a clasp upon both the bicuspid and the molar, with a lug resting upon the occlusal surface of the molar.

Fig. 332 shows the two central incisors with two staple cribs.

Fig. 333 shows crib and clasp ready for constructing a vulcanite denture. These cribs were necessary because attachment had to be made to a fixed bridge.

Fig. 333

Fig. 334

Fig. 334 shows a partial lower case with gold clasps carrying three natural lower incisors. This method is possible when the teeth are recently extracted and free from decay. Teeth by this method are usually those lost by pyorrheal conditions. The natural teeth must not be put through the vulcanizer, as the heat and sulphur will completely disintegrate them. The tooth or teeth are cut

off the desired length to fill the space and the pulp chambers enlarged to loosely admit a 16-gauge clasp gold wire. If the tooth is to be attached to a gold base-plate, the wire should be aligned and soldered to the base-plate and the tooth cemented to the pin with oxyphosphate of zinc. If the teeth, as in the case, are to be attached to a vulcanite base-plate, a small piece of gold plate is soldered upon the end of each of the posts. The cervical end of the teeth are wet with water, placed upon the posts, and imbedded and aligned in

Fig. 335

Fig. 336

the softened wax. The wax is conformed and smoothed about the teeth, which are lifted off the posts, and the case completed in vulcanite. Fig. 335 shows the vulcanite base-plate ready for cementing the teeth.

Fig. 336 illustrates the metal portion of a bar lower with a cast shoe for the left bicuspids and molars, a half-cope for the right second bicuspid, and spring clasps for the right second bicuspid, left second bicuspid, and left second molar. A tang is also shown for attaching the missing incisors.

Fig. 337

Fig. 338

Fig. 339

Fig. 337 is a bar lower having two incisors attached with vulcanite to a tang. It may be seen that the attachment to the right second bicuspid consists of a cope and spring clasp.

Fig. 338 has a cast ferrule telescoping three crowned teeth.

Fig. 339 illustrates the method of reinforcing the tang of the clasp. The tang is attached to the clasp, as shown in Fig. 189, and then conformed to the cast. It is removed from the cast, supported upon the magnesia soldering block, and the reinforcement of wire or a piece of scrap gold plate soldered on. This reinforcement is necessary to prevent the clasp (in time) breaking from the tang.

Fig. 340

REPAIRING GOLD PLATE WORK.

If the denture to be repaired is soldered work only, it is repaired by investing and soldering. If it is combination work of gold and vulcanite and the gold is broken it will be necessary to remove the vulcanite, solder, and rebuild the vulcanite portion. If it is a clasp broken, which often happens, it may usually be repaired by fitting another clasp to the tooth, soldering a lug to it to fit into a filed groove in the continguous vulcanite, and attaching with vulcanite.

PARTIAL PLATE DENTURES VERSUS BRIDGE-WORK.

Undoubtedly the trend of the times is toward the revival of the use of partial plate dentures, and the elimination of fixed bridge-work. This is logical and just in view of the

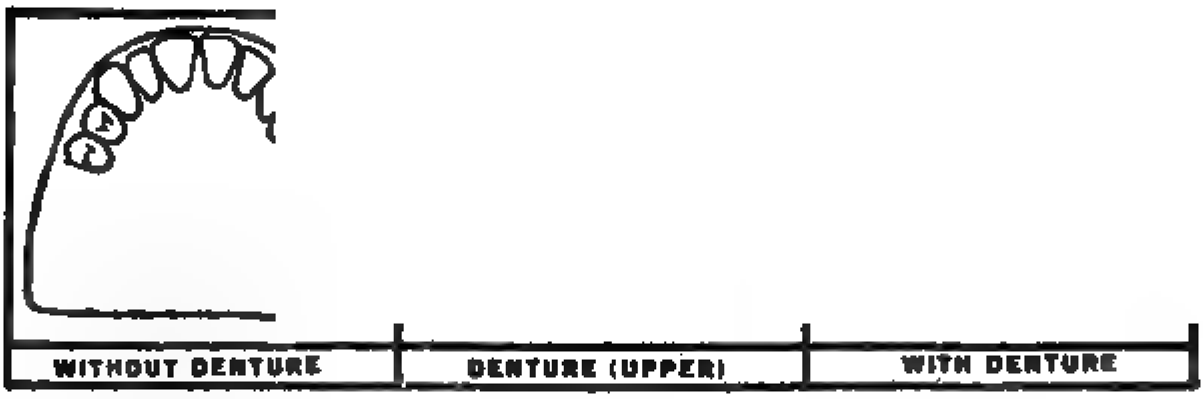

FIG. 341

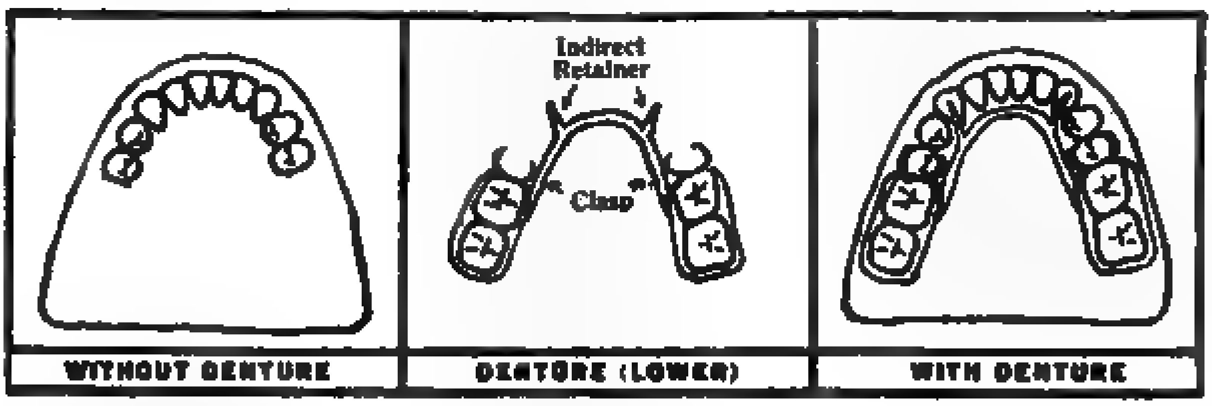

FIG. 342

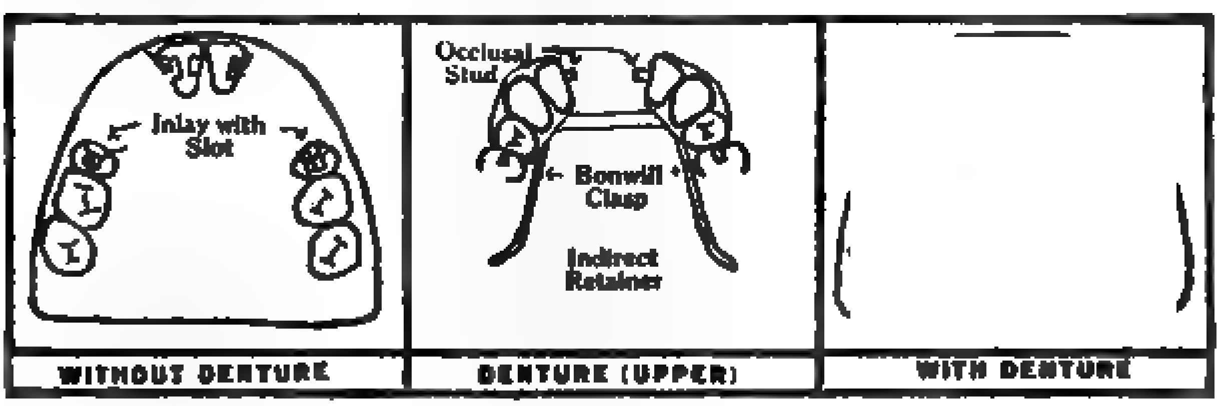

FIG. 343

FIG. 344

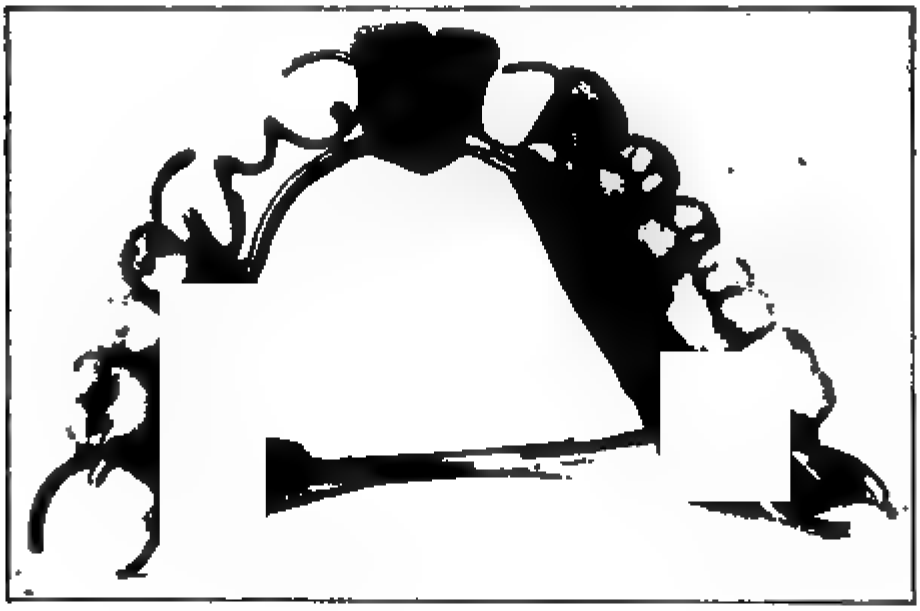

FIG. 345

FIG. 346

FIG. 347

modern status of sepsis and asepsis and accepting as a fact the importance of the mouth as a focus of infection. During the year, 1916, two notable contributions were made to dental literature on partial plate dentures. One by Dr. W. E. Cummer,[1] Professor of Prosthetic Dentistry and Applied Physics, Royal College of Dental Surgeons, Toronto, Can., and the other by Dr. J. Wright Beach,[2] of Buffalo, N. Y.

Professor Cummer presents a very complete system for partial dentures, consisting of direct and indirect retainers for saddle bases. These retainers consist of clasps, lugs—both rest and inlocking, and bars—both connecting and extending; also crowns, inlays and the Roach ball-and-slit tube attachment.

A study of the following illustrations will explain the principles of use and suggest unlimited application.

Figs. 340 and 341, bilateral restoration, show the simplest form of clasp for direct retainer and extension rest stud for indirect retainer.

Fig. 342 shows a more complicated application utilizing clasps, slotted inlays for studs and extension rest studs.

Fig. 343 illustrates the use of the Roach attachment as the direct retainer and a double inlocking stud as the indirect retainer, for a unilateral restoration.

The Beach system is essentially a method of retaining saddle bases of either vulcanite or gold by bars, clasps and stays. The bars, clasps and stays are all made of round and oval wire of 11 to 20 gauge.

A close study of Figs. 344, 345 and 346 will be self-explanatory to the practitioners, and will suggest a variety of modifications. For the helpfulness of the student it may be well to suggest that the festoon stays are made in units and the units added one at a time with solder, each clasp is also a unit.

[1] "Oral Health" (Toronto) March–April and June, 1916. Pacific Dental Gazette, July, 1916. Journal Allied Dental Societies, September, 1916. Bulletin California State Society, November 1816. Dental Summary, March, 1917.

[2] "Dental Summary" (Toledo), June, 1916.

CHAPTER XII.

TIN BASE-PLATE.

THE cheoplastic or tin method for forming base-plates was given to the profession about 1855 by Dr. A. A. Blandy. Recognizing that a casting process would provide the most perfect adaptation, and that pure tin was an acceptable metal to the tissues, the profession readily accepted the method. The later methods have been somewhat more simple than the earlier one.

The metal consists of tin alloyed with such metals as bismuth, silver, gold, and possibly cadmium and antimony. Several of the alloys on the market were proprietary, and their composition not published. The formulas of the published ones are:

Kingsley's alloy: Tin, 16 ounces; bismuth, 1 ounce.

Reese's alloy: Tin, 20 parts; gold, 1 part; silver, 2 parts.

Bean's alloy: Tin, 95 parts; silver, 5 parts.

Watt's and Weston's alloys, proprietary preparations, are the principal ones on the market. These are both low fusing (about 400° F.) and interchangeable in manipulation. The method is mostly confined to lower dentures. Since the introduction of successful casting of pure aluminum there will be less occasion for its use. As the aluminum casting is better understood, it should entirely supersede the tin alloys, as it is much stronger, more cleanly and durable than the tin alloys.

Technic. — The same investment compound used for casting aluminum serves for the tin alloys. The necessary implements are a Watt flask (Fig. 347) and a ladle or large spoon.

The wax model is formed the same as for an aluminum base-plate, flasked in the first half of the flask (Fig. 348),

paying no attention to the gates *B* and *C* at this time; and when the investment is hard, varnish and fill the second half, having the wax model wet and jarring the investment compound well into place. The flask is opened the same as a vulcanite flask (Chapter VI) and wax removed. The investment material is removed from the funnels and a small and large gate cut as shown at *B* and *C* respectively. The two sections of the flask are placed over a piece of sheet-iron

Fig. 348

on the gas stove and dried until no steam is given off. They are then bolted together, and an ingot of the tin alloy melted in the ladle or spoon over a Bunsen burner and poured into the large gate until the metal appears at the small gate. Should there be any bubbling the flask should be grasped by the handle and lightly jarred against the bench until the bubbling ceases. The casting should stand until it is cold, and then be opened. However, after the metal has partially cooled, it may be placed in cold water and the

cooling expedited. The sprues are cut from the casting with a mechanical saw, and the filing done with a vulcanite file. It is polished the same as vulcanite.

Fig. 349

CHAPTER XIII.

CONTINUOUS GUM DENTURES.

By this term is meant a base-plate of platinum, the outer surface of which is covered with a continuous layer of porcelain.

It is true, the term might equally well, or better, be applied to vulcanite or celluloid; but the term was applied to the enamelled platinum before the introduction of the other materials, and is universally accepted as applicable to the enamelled platinum only; therefore to call any other material by this name is a manifest deception.

The French were the earliest experimenters in porcelain work for artificial dentures; but it remained for Dr. John Allen, of Cincinnati, and later of New York City, to perfect the material and method of construction. He perfected the process in 1846. The furnace work of the early days was difficult and hazardous. Within a decade of the invention of continuous gum work vulcanite was placed before the profession. Because of its inexpensiveness and ease of construction it nearly drove the more expensive and better methods from the field. However, in the last quarter of a century the facilities for constructing dentures of the better quality have been so much improved that they are gradually coming into their own. So much so that any student who is desirous of equipping himself for practice among the better class of patients should be thoroughly conversant with the construction and merits of continuous gum dentures. It is without doubt the most cleanly, healthful, and esthetic of any material or denture placed in the mouth. It is composed of mineral matter only and these of the greatest purity and compatibility to the human economy. The materials entering into its composition are platinum, iridium, gold, and high-fusing porcelain.

Porcelain.—Porcelain suitable for this work is procurable at the supply houses. It is known as "Continuous Gum Body" and "Gum Enamel." The body is in boxes containing one ounce each, and the enamel one-half ounce to the box. Close's product (modified Allen formulas) is the one

Fig. 350

most commonly used. The body fuses at 2300° F., and the enamel about 100° lower. They are of the same composition, with more flux, as porcelain teeth.

Equipment.—For an office equipped for gold work nothing is required except a furnace for baking the porcelain. If the electric current is to be had, one of the various electric

furnaces upon the market is to be preferred; otherwise a gasolene-burning furnace, of which there are several makes.

To Dr. L. E. Custer, Dayton, Ohio, belongs the credit of inventing and demonstrating the first dental electric furnace. His first demonstration was before the Ohio State Dental Society in 1894. Since that date other furnaces possessing excellent features have been invented, but none have surpassed the Custer furnace in scientific construction.

Fig. 351

Fig. 349 shows the furnace and illustrates the method of wiring so as to produce an economical and evenly distributed heat.

An auxiliary instrument to the furnace is the pyrometer. To Dr. Weston A. Price, of Cleveland, belongs the credit of adapting this instrument to the dental furnace. Fig. 350 shows the Price furnace and pyrometer complete. The instrument is the thermopile adapted to this special use, and requires little experience to fuse the porcelain well; however, judgment must be exercised even with this perfect instrument. Without the pyrometer the operator must depend

upon his eye to determine the heat. Either with or without the pyrometer the operator must have a definite method of manipulating the rheostat, and use judgment. The voltage of any current varies within certain limits, which will have an influence indicated by the pyrometer, and in connection with the rheostat can be better controlled than by the eye. Nevertheless, an operator of average discernment and ability

Fig. 352

should, with a little experience, be able to produce excellent results with an electric furnace, either with or without the pyrometer.

Fig. 351 shows one of the gasolene furnaces.

TECHNIC OF CONSTRUCTION.

Plaster impression, cast, model, die, and counter-die are required, the same as for a full-gold denture.

A base-plate of pure platinum 32-gauge (B. & S.) is formed. Care should be taken (well-oiled die and counter) not to contaminate the platinum with base metal. The base-plate swaged and trimmed is tried in the mouth and tested for palatal length, and freedom from impingement upon the muscle attachments. The peripheral border per-

fected and the adaptation inspected, it is returned to the die for forming a reinforcing piece for the palatal border. Should the adaptation not be satisfactory, it must be corrected, at this stage of construction, even to the extent, if necessary, of obtaining a new impression and constructing a new die and counter.

The palatal reinforcement should be ¼ of an inch wide in the median line and slightly taper toward and terminate at the tuberosities (Figs. 353 and 355). This doubler is swaged of 30-gauge (B. & S.) pure platinum. After being swaged it is placed upon the base-plate and swaged. The anterior border of the doubler is turned up with pliers at an angle of 45 degrees so that in the finished piece the porcelain will be engaged under this edge of the doubler. The doubler will be distorted in bending the edge; this is corrected by wiping, pickling, annealing, and burnishing the doubler to the base-plate. The bending and burnishing are alternated until suitable adjustment is obtained. The base-plate and doubler are cleansed and clamped together with wire clamps; pure gold, 35-gauge, cut in small pieces, is placed without flux, under the turned edge and melted with the blowpipe so as to draw the gold as solder outward and perfectly attach the doubler to the base-plate. An 18-gauge iridioplatinum wire is soldered with 35-gauge pure gold to the periphery of the plate, from tuberosity to tuberosity, in the same manner as wiring a gold plate. The charcoal soldering block should not be used, as carbon is detrimental to platinum. The magnesia or asbestos block will serve the purpose. Flux is unnecessary as a cleanser, as noble metals only are used; but it may serve to hold the solder in place. No more gold should be used in continuous gum dentures than is necessary to unite closely fitted joints. Some advocate the use of platinum solder (gold with 20 to 25 per cent. of platinum) and the oxyhydrogen blowpipe for soldering platinum for continuous gum dentures. This is quite unnecessary, as the pure gold will alloy with the platinum base-plate while baking the porcelain; however, close-fitting joints are necessary, probably more so with pure gold used as solder than with platinum solder,

The reinforced platinum base-plate is used in obtaining the wax occlusion and contour models, and mounting upon the antagonizor. Teeth suitable for the case (Figs. 218 and 352) are selected and mounted in wax. The case is ready for trial in the mouth. It should be inspected for adaptation, contour, and cosmetic effects, which being satisfactory, the case is ready for soldering the teeth to the base-plate.

FIG. 353

Soldering the Teeth.—It is quite essential that the waxed trial denture should be well contoured to develop all the restorations required. A record is made of the thickness of the gum portion at the median line, at the center of each cuspid eminence, and of the buccal contours (if any are required) by measuring with calipers and making indicative marks on paper. The wax is cut away with a warmed wax knife, from the labial and buccal surfaces, leaving the wax on the lingual surface intact to support the teeth while investing (Fig. 353).

An investment suitable for this work is composed of any coarse silica compound and approximately one-fifth of its bulk of asbestos; either the long fiber or the short (tenax) fiber may be used. A soft-iron wire ring of 15 gauge is formed to place about the denture in its largest plane and be free of contact by $\frac{1}{4}$ inch at every point. A sufficient quantity (half-bowlful) of investment is wet up to a soft

putty consistency. The intaglio of the denture is filled and a portion quickly spread over the labial and buccal surfaces

Fig. 354

Fig. 355

of the teeth; the balance of the investment is spread on the flat surface, upon which plaster casts are formed; the partially invested case, with its exposed surface upward, is pressed into it so that the most prominent points are covered by at least ¼ inch; the wire ring is placed about opposite the cervical portion of the teeth; and the spatula used to draw the spread-out investment up over the wire ring and the morsal ends of the teeth, so that all will be strongly covered. The wire serves two purposes, as a strengthener and as a guide to thickness. When the investment is hard it is set in a warm place to dry and soften the wax, which is picked out and the pins of the teeth bent upward. Fig. 354 shows the invested case with the lingual surface of the base-plate and the teeth exposed; also some of the pins are seen bent upward.

Reinforcing Wire.—A 12-gauge iridioplatinum wire is bent to fit closely under the pins of the teeth and with the ends in contact with the tuberosities. The long platinum pins of the teeth are bent around the reinforcement wire, thus holding it securely in place. The ends of a truss wire, of iridioplatinum 18-gauge, is placed in contact with the reinforcing wire in the proximity of the cuspids, and with its center resting upon the base-plate in the median line near the crest of the alveolar ridge. A small piece of pure gold (for solder) is placed at each point of contact of the wires, pins, and base-plate. The case is heated up to bright redness, when the gold is thoroughly fused with the needle flame of blowpipe. Figs. 355 and 356 show two views of the case, soldered and removed from the investment; thus giving a better idea of the palatal reinforcement, peripheral finishing wire, lingual reinforcement, and truss wires as soldered together. The case should be tried upon the die, and if warped it must be readjusted by pressure with the fingers, and by the aid of the horn mallet, copper hammer, and plate burnisher. However, if the case has been properly handled there should be no warpage. The skeleton denture is cleansed with a laboratory plate brush and water. It is placed upon the antagonizor for assurance that the teeth are in proper occlusion.

It is apparent that the peculiar formation of the porcelain teeth, designed for continuous gum dentures, is for a purpose. The single long pin is to furnish a flexible attachment, and

Fig. 356

the root portion of the artificial tooth is to provide contact with the base-plate; also as an aid in contouring, and in controlling the shrinkage during the enamelling. When

Fig. 357

testing the occlusion if any of the teeth are found misplaced they may be brought into position by bending the platinum pins, although soldered to the reinforcement wire. At the

same time the root portion of the tooth should be in contact with the base-plate; nevertheless, if either end of the tooth

FIG. 358

FIG. 359

is to be out of the ideal position, it should not be the morsal end. Fig. 357 shows a case wherein the apices could not be in contact with the base-plate and Fig. 358 shows the occlusion.

APPLYING THE PORCELAIN.

Body.—A portion of continuous gum body (about ½ ounce) is saturated with water to the consistency of stiff mud, and a portion applied with a thin spatula to the base-plate about the apices of the teeth. The case is lightly held by the index finger and thumb of the left hand, and the body jarred and settled into place by tapping with a light instrument upon the periphery of the base-plate. More body is added and jarred until all space between the base-plate, reinforcement wire, and teeth is compactly filled. The excess moisture upon the surface, after each jarring, is absorbed with a napkin. The buccal, labial, and lingual surfaces are covered with the body; a portion at a time is covered with the napkin and compressed between the thumb and finger, the finger in apposition to the maxillary surface. Care should be exercised that no portion is more thickly covered than is desired for the completed denture, and no attempt should be made at contour. Any body material upon the base-plate or teeth when not required must be removed. A pointed thin-blade spatula and a small ox-hair brush will be useful, also an artist's medium-small pencil brush moistened and drawn to a point (between the lips) is useful in making a clean-cut gum outline.

Controlling Shrinkage.—As porcelain shrinks about one-sixth of its volume in fusing, it must be controlled, or the teeth will be drawn out of place. It is controlled by slitting the body so that it will draw about fixed centers. This is done with a thin spatula, cutting entirely through the body to the base-plate, thus making each tooth a fixed center. Fig. 359 shows the lingual surface slit. Fig. 360 shows the large spaces formed on the buccal surface by the slitting, and shrinkage in baking.

First Baking.—With a Custer furnace the case is placed in the furnace with the teeth upward. The lever of the

rheostat is advanced one stop and the case given ten minutes to dry, after which the lever is advanced two stops every five

FIG. 360

minutes, and upon the last stop it is left for one to ten minutes, as may be necessary to produce the "biscuit" bake; that is, granulated with a very slight glazed appearance. The time will vary with the condition of the current and the

FIG. 361

number of times the furnace is opened for inspection. If a pyrometer is being used the lever must be advanced to bring

the heat to the desired temperature in a given time, which should be established for each current supply and furnace. Every make of furnace will furnish instructions for use. The current is turned off and the furnace opened for a minute or two to stop the fusing, when it is closed until cold. The denture is placed upon the cast, and if warped it must be corrected. The anterior edge of the palatal reinforcement is burnished down. Checking of the body does no harm.

Second Body.—The case, being cold, is wet and body applied to fill all spaces caused by shrinkage, jarred, and excess moisture absorbed with the napkin. Body is then added to form all contours. The crest of each eminence should be the full thickness of its corresponding caliper record, for the shrinkage will provide space for the glazing enamel. Any large restoration will require exaggerated body additions, as the shrinkage will be greater than the enamel added.

Second Baking.—The case is placed in the furnace, dried, and heated up the same as the first time, but carried to a higher degree of fusion than the first time (probably about 50° F. higher). The fusion is checked, and furnace closed until cold.

The case is examined for shrinkage; if there are small shrinkage spaces only they are filled in with body and not baked, but if there are large crevices the case should be baked again at about the temperature of the first bake.

Enamelling.—As all contours, including gum margin festoons, and rugæ, with their corresponding depressions, were developed in the second coat of body, it is necessary only to place over the surface a smooth layer of gum enamel to produce the light and dark shading characteristic of artistically constructed continuous gum dentures. The entire surface of the body should be covered with the gum enamel wet with water and smoothed with an oval-faced burnisher. The gum margin must be neatly pencilled and all granules of the gum material removed from the teeth.

Third Baking.—Ordinarily two bakings only will be required for the body and one for the enamel. The enamel coat should be heated up with the same care as the body

and fused until the surface has a "watery" appearance when looked at across the surface, in the hot furnace. The furnace is opened long enough to stop the fusion, closed, and left until cold.

Fig. 362

Polishing.—The porcelain will come from the furnace with a perfect polish, but the platinum may be buffed with

Fig. 363

the felt buffer and pumice, and glossed either with the soft brush wheel and whiting, or burnished. Figs. 361 and 362 show the completed work.

Fig. 363 shows a continuous gum section of five teeth attached to a vulcanite base; also the clasps.

Fig. 364

REPAIRING.

Continuous gum work lends itself to the most perfect repair of any artificial denture. It must be first burned out, that is, scrubbed with soap and water, invested completely in the silica-asbestos compound, heated up gradually to a high red heat so as to remove all organic matter; when new material may be added and fused securely to the old.

A broken tooth may be repaired by building up with any of the moderately high-fusing enamels used in inlay work, or by grinding out the remains of the tooth, setting in either a continuous gum or vulcanite tooth packed with body and baked; gum enamelled and baked. At all bakings the same attention (as described) should be given to heating and tempering (cooling) the porcelain.

Cracks are repaired by placing on a cast, chipping off the porcelain about the crevice, then fill and bake.

CHAPTER XIV.

INTERDENTAL SPLINTS.

An interdental splint is an appliance made of either metal or vulcanite and placed between the jaws to support a fracture of either or both the maxilla and mandible.

Interdental splints in conjunction with submental compressors and occipitomental bandages have been used by surgeons in the treatment of fractured jaws since 1780.

Drs. F. B. Gunning, of New York, and J. B. Bean, of Atlanta, Ga., were the first to describe methods of constructing interdental splints of vulcanite.

When a dentist is called upon to construct an interdental splint it will be in consultation with a surgeon. He should, in justice to himself, make a critical examination of the case and determine if an interdental splint is indicated or if some other method will better serve the patient. If the fracture is of the maxilla only, and the teeth are nearly all *in situ*, it is quite probable that forcing the fractured portions into place and holding the lower teeth firmly against them with a cotton-padded external plaster splint and bandage is the preferable method of treatment. Fracture of the mandible *may be* best treated by binding the teeth of the mandible to those of the maxilla with bands and wires designed for orthodontia purposes, in conjunction with an external plaster compress and bandage. If the patient is wearing a full upper and lower artificial denture, the dentures may be securely united with vulcanite, the upper incisors removed for a feeding space, and used for the splint. However, if an interdental splint is determined upon it should be constructed as recently described by Dr. George B. Snow, of Buffalo.

THE CONSTRUCTION OF INTERDENTAL SPLINTS.

Interdental Splint.—"An interdental splint, when properly constructed, forms an efficient and satisfactory means for treating fracture of the mandible, and the Snow face bow and New Century or Gritman antagonizor are absolutely necessary for the attainment of the correct alignment of their occluding surfaces. For this reason a short description of the correct method for this construction is appended.

"These instructions apply to the construction of the 'Gunning' splint. This separates the jaws and receives both the upper and lower teeth. It is retained by means of bandages, and fixes the mandible immovably. It has a wide range of application, and is the most satisfactory splint for general use. The Snow face bow is absolutely necessary for its construction, as the casts must be placed in the antagonizor at the same distance from its joints that the alveolar ridges are from the condyles, or the bite cannot be opened for the reception of the splint with any certainty of having correct occlusion when the fracture has united. The fact that the Snow face bow has not been used is the common cause of failure in interdental splints, as they have heretofore been constructed.

"Impressions of the teeth, both upper and lower, are first to be secured. These are better made in plaster, rather than modelling compound, for the plaster is more easily managed and is less subject to distortion. Very shallow impression trays should be used, the *B* mouthpiece of the face bow answering the purpose, and only plaster enough used to obtain an impression of the teeth to the gum line. No attempt need be made to correct any deformity which may be present, and the operation, if properly conducted, will be almost painless to the patient. The impression must take in *all the teeth present* in the mouth, for if the third molars are not included, they will not be covered by the splint, and will elongate while it is in use, and so interfere with occlusion. Fill the palatal portion of the upper impression with sheet wax or paper just above the gingival line and run a *thin cast.* Run a thin horseshoe cast in the lower

impression. With a Swiss saw cut this cast at the point of fracture, and adjust the parts so that they make correct occlusion with the teeth on the upper cast. Secure the two casts together with a *very little* sticky wax. Run a little plaster on a piece of paper and set the lower cast into it, to hold its parts in their correct relation.

"After taking the impressions, place a little soft wax in the *B* mouthpiece and use the face bow as heretofore directed. Place the upper cast in the antagonizor by means of the face bow, and it will be at the correct distance from the antagonizor joints, and when the lower cast is antagonized, their separation to accommodate the splint can be safely made, and normal occlusion secured when fracture has united.

"Cover the teeth with No. 60 tinfoil, letting the tin extend beyond the teeth, buccally and lingually, and cutting the tin so that it can be put on without crumpling. Follow with one thickness of sheet wax, covering the teeth, both upper and lower, to the gum line. Separate the two wax plates (open the bite), so that a lead-pencil will pass between them in front. Connect them at the sides with wax, leaving an opening in front extending from cuspid to cuspid.

"A No. 3 Snow flask (or a box flask) will receive both casts and splint. Set one cast, the splint being in place, the plaster covering the edge of the wax, both buccally and lingually. Trim and soap not only the usual parting surfaces of the invested cast, but the splint and palatal surface of the other cast as well. Holding the loose cast upon the splint, run plaster into the space between the two casts, and build it up around the sides and rear to the edge of the wax. Trim to an incline to the edges of the flask all around. Soap. Place on ring and fill. When separating the flask have it warm enough to soften without melting the wax. Rap the edge of the flask to dislodge the centerpiece. Remove and save the wax, and find quantity of rubber required by immersing the wax in a glass of water. Pack and vulcanize. The tinfoil being left upon the casts, the impression of the teeth in the splint will be smooth, and also larger than the teeth themselves by the thickness of the foil used. This

is why the use of thick foil is directed, as the additional space gained by it renders the splint more easy of adjustment."

Fig. 365

Fig. 364 represents both the wax model splint and the finished vulcanite. Fig. 365 is a diagram showing a cross-section of the flasked case. The flask is designated by *F;* the

Fig. 366

casts, *M;* the plaster encasement by *P;* tinfoil covering the teeth with extension beyond the wax splint by *T;* and the wax model of splint in the center.

Fig. 366 illustrates a splint provided with arms of steel wire, ⅛ inch in diameter, arranged to come "out of the mouth when the splint is in position, passing back along the cheek on a line with the teeth." This splint was invented by Dr. Norman W. Kingsley, and the description of it is from his valuable work on *Oral Deformities*. The splint is retained in position by the submental compress attached to the side bars.

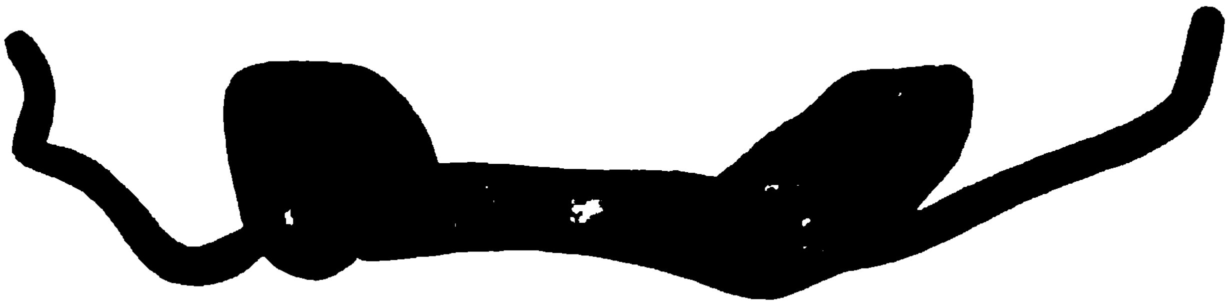

Fig. 367

"It will be seen that this splint covers the lower teeth only, and that its top occludes with the upper teeth to admit of mastication. The construction of such a splint is accomplished by placing upper and lower casts in an antagonizor, forming the wax splint as before described, arranging the occlusion so that the contact of the upper teeth will be uniform, imbedding two stout wires with flattened ends in the wax, so that they will bear the strain which will be required of them while the splint is in position. The particular flask best adapted for the vulcanizing of interdental splints is oblong in form, and is larger than ordinary vulcanite flasks; it is known as the box flask."

CHAPTER XV.

CLEFT-PALATE APPLIANCES.

By cleft-palate is meant a defective condition of the roof of the mouth, forming an abnormal opening between the oral and nasal cavities. The cleft may be of the form of a fissure or of a rounded hole. The cleft may be either congenital or acquired. The congenital cleft is due to defective fetal development, but not accounted for. The acquired cleft may be due to either accident or disease. The extent of the cleft may be from a slight cleft of the uvula to one extending through the soft and hard palates and the alveolar process; also may extend through the lip (hare-lip). If there is no hare-lip complication, the defect is noticeable only in speech, in which there is an unmistakable nasal intonation. The defect is amenable to both surgical and mechanical treatment, the latter of which only is considered in this chapter.

Apparatus.—There are two types of apparatus for restoring the defects of the roof of the mouth, known as *obturator* and *velum*. Of these, Dr. N. W. Kingsley says: "An obturator is a stopper, plug, or cover, hard, non-elastic, and stationary, fitting to an opening with a well-defined border and shutting off the passage. Such instruments are applicable to perforations of the hard or soft palate resulting from accidents or disease, but they are rarely applicable to a congenital fissure of the velum. An artificial velum is not a temporary stopper, but an elastic, movable valve under the control of the surrounding adjacent muscles, closing or opening the passage at will, and is applicable to congenital fissures, occasionally where the soft palate has been destroyed, but never to perforations of either the hard or soft palate."

Dr. Kingsley further says: "In most cases of congenital defects, the patient will acquire correct articulation more easily and more certainly with an elastic velum scientifically

adjusted than with any other form of appliance, because it more nearly resembles the action of the normal palate and will more readily fulfil its function.

"That in a great majority of cases of a like defect a patient will never acquire distinct articulation with an obturator.

"That where a patient afflicted with a congenital absence of the palate has overcome the difficulty by using an artificial velum until clear and distinct articulation has been acquired, he may change the velum for an obturator, and continue to articulate properly.

Fig. 368

"That of all obturators to supply deficiencies of the soft palate and induce correct articulation, the one introduced by Suersen contains the truest principles and is best adapted to the purpose."

Fig. 367[1] gives a view of a patient's mouth, showing part of the cleft palate and the appearance of the lip after being operated upon for hare-lip.

[1] Figures 367, 368, 369 and 370 are of cases of Dr. Chalmers J. Lyons, of the University of Michigan.

Fig. 368 is an illustration of a congenital cleft extending through the soft and hard palates and also the alveolar process.

FIG. 369

FIG. 370

Fig. 369 shows a cleft of the soft and hard palates, and alveolar process depressed, but not cleft.

Fig. 370 shows a cleft of the soft palate only.

The artificial velum should rarely extend into that portion of the cleft extending through the alveolar process, which may better be filled with the hard vulcanite.

FIG. 371

Synopsis of Technic for Constructing Velum and Supporting Base-plate.—Impression for velum, cast, preparation of cast for making model of velum, making model velum, adjusting model velum to mouth, flasking model velum, converting plaster encasement into metal encasement, vulcanizing velum, finishing velum, impression with the velum *in situ* for the retaining base-plate, constructing the retaining base-plate, and attaching the velum.

Impression of the Cleft.—An ordinary impression tray will not suffice for a congenital cleft palate. A spoon with the convex surface of the bowl upward well serves for a tray to carry the plaster, or one of the two methods described by Dr. C. S. Case, of Chicago. He uses the index finger with soft modelling compound wrapped about it as the foundation for his impression. Having obtained an imprint of the cleft in the compound, it is chilled and carved so that it may be

held in the cleft without contact with the tissues. It is then covered with a soft mix of impression plaster, carefully

Fig. 372

Fig. 373

adjusted, and held until set; then removed by forcing it backward until relieved of the anterior margin of the cleft. Fig. 371 shows the completed impression as taken from the

mouth for a cleft of the palate only. The impression is varnished and filled, as shown in Fig. 372. Fig. 373 shows

Fig. 374

Fig. 375

the cast after removal of the impression. Fig. 374 shows the cast carved for use. Fig. 375 shows the cleft filled with

Fig. 376

Fig. 377

Fig. 378

modelling compound carved to thin edges as a model for the velum. Fig. 376 shows the nasal surface of the same. Fig. 377 shows a side elevation of the model velum. Fig. 378

Fig. 379

Fig. 380

shows the finished velum in the plaster cast. Fig. 379 shows the skeleton base-plate upon the plaster cast. Fig. 380 shows

Fig. 381

Fig. 382

Fig. 383

the wax model base-plate. Fig. 381 shows a side elevation of the finished base-plate. Fig. 382 shows a side elevation of combined base-plate and velum. Fig. 383 is the lingual surface of the same.

Most of the steps are comprehensible from the illustrations; however, there are several that are not and need elaboration.

Fig. 384

Velum Model.—The velum model is the first step after the impression that needs further consideration. Softened modelling compound is shaped in the carved cast by the thumb and finger. The anterior or body portion of the velum is left thick for a body, while the posterior or curtain portion and the flanges are made very thin with attenuated edges. This is accomplished, so far as possible, by molding the softened material with the fingers, after which it is further reduced with a vulcanite scraper and sandpaper. It is finished with a cloth wet with a solvent, as alcohol.

Adjusting Model Velum to the Mouth.—A hole to admit a 14-gauge wire is drilled through the body of the velum model from the oral to the nasal side. A wire with $\frac{1}{4}$ inch of one end bent at right angle is fitted to the drill-hole in model; the other end of the wire is looped to form a handle.

This wire is used to handle the model while adjusting it to the cleft. The body of the model should be kept hard, but the curtain and flanges may be softened as required by dipping in warm water. It is adjusted by the patient swallowing, trimming away excessive material, and molding with the finger. Additions may be made by tracing on with a pencil of modelling compound. The velum must be so formed that in the act of swallowing it will entirely close the opening between the oral and nasal cavities. The desired form and adaptation being obtained, it is chilled and made smooth. It is then ready for flasking.

Flasking the Model Velum.—A small-sized bolted vulcanite flask is used. The inner surface of the flask is smoothed of any roughness by grinding, and smeared with vaselin so that the encasing plaster may be easily removed. The model must be so encased in the flask that the sections of the encasement plaster may be removed, molded, and reproduced in metal. This will require three sections of the encasement plaster. Each piece of the encasement plaster is flasked in a suitable flask (box) with silica investment compound and reproduced either in Babbitt or type metal. The operation is simple, but judgment must be exercised both in flasking the velum model and the sections of the plaster encasement. Fig. 384 shows the three sections of the Babbitt metal castings. Fig. 385 shows the bottom and middle castings assembled in one-half of the flask and the third section in the other half of the flask.

The encasement in the box flask must be heated to dry it of all moisture so that steam will not be formed in filling with the molten metal.

The surfaces of the castings, which are to give form to the artificial velum, must be carefully polished and burnished, as they should produce a finished surface upon the velum.

A hole must be drilled in both the upper and lower sections of the castings to carry a wire former for the hole in the body of the velum to admit the coupling standard, as seen in Fig. 385. One end of the wire is cemented into the casting; the other end of the wire enters the hole in the other section of the casting, but is not fastened.

The wire former should be one or two sizes smaller than the coupler wire.

FIG. 385

The surfaces of the metal mold must be soaped and dried each time it is to be used. This is to prevent the velum vulcanite adhering too closely.

FIG. 386

Packing Velum Rubber.—The metal mold should be as warm as the fingers can be held upon without discomfort. It is packed, without enmeshing air, with velum rubber (caoutchouc, 25; sulphur, 5 parts), and vulcanized, the same

as hard vulcanite. The packing should be carefully done, so as to have as little excess as possible, which will force its way out of the metal encasement.

Finishing the Edges of the Velum.—This can be done only by trimming with sharp scissors, searing with a hot iron, and rubbing with chloroform.

Impression for the Retaining Base-plate.—It is necessary that the artificial velum should be held accurately in place while taking the impression for the retaining base-plate. The surface covered by the impression must include the thick body portion of the velum, the vault portion upon which the supporting base-plate is to rest, and the teeth to which the base-plate is to be clasped. The velum is supported by means of a 13-gauge soft-iron wire. The end of the wire is engaged in the coupler hole and its shaft conformed to the vault and about the buccal surface of the teeth, and then protrude from the mouth, the external end being looped for a handle. The object is to so bend and shape the wire that it will support the artificial velum, and that no part of it, except the portion near the cleft, shall be engaged in the impression. The selected tray is adjusted. Should the palatal portion not extend sufficiently backward, it should be extended by an addition of wax or modelling compound. The impression is then taken in plaster. The impression with the artificial velum in place is varnished and poured with silica investment compound. Upon this cast the clasps are shaped and the clasp gold-wire skeleton is formed. The joinings of the various pieces of metal are covered with wax, and the rest of the wire is covered with investment compound, leaving the waxed joints wide open. The cast about the velum is cut away and the velum removed from the coupler wire. Investment is added to the exposed end of coupler wire. The case is heated and soldered. The skeleton frame with velum attached is adjusted to the mouth and impression taken for the vulcanite base-plate. The impression should extend at least $\frac{3}{8}$ inch back of the coupler pin. The impression will probably be much broken in removing from the mouth. The impression and metal skeleton are assembled without the

velum and the impression varnished and poured with plaster (Fig. 379).

If a gold base-plate is desired, the first impression with the artificial velum in place is poured with plaster (in place of investment compound), a die and counter formed, the gold base-plate constructed, and the coupler pin attached with solder.

Fig. 387

Fig. 388

Fig. 389

Suersen Obturator.—This obturator is hard vulcanite hollow bulb made to fill the cleft, and upon which the divided palate glides while speaking and swallowing. The principal merit of this apparatus is that it is cleanly and durable. Reference has been made to Dr. Kingsley's statement as to its usefulness. Figs. 386, 387 and 388 illustrate

three Suersen bulbs (obturators), one of which is attached to a base-plate retainer.

Velum Obturator.—A late invention for the relief of this distressing deformity is Dr. Case's velum obturator. This instrument consists of a peripheral roll and an intervening

Fig. 390

Fig. 391

septum of velum vulcanite. Figs. 389 and 390 illustrate this apparatus. A full detailed description of the apparatus is to be found in Dr. Case's book.

Case's Hard Velum Obturator.[1]—This is a very ingenious and highly successful creation by Dr. C. S. Case. It is

[1] Brophy's Oral Surgery, and Dental Items of Interest, October, 1916.

adapted to those clefts extending some distance into the hard tissue. It is of similar form to preceding velum obturator, but is constructed of hard vulcanizable black rubber and has no attachment to the teeth.

Fig. 392

Fig. 393

Denture Obturator.—Figs. 391 and 392 show two views of a cast aluminum denture obturator made necessary by a

surgical operation for the removal of a tumor of the maxillary sinus.

Figs. 393 and 394 are two views of an obturator made necessary for a case in which the entire left maxillary bone, except the orbital plate, was removed because of a sarcomatous growth. When the patient was first seen the opening

Fig. 394

Fig. 395

made by the operation extended from the mouth to the pharyngeal cavity. It was about $\frac{3}{4}$ inch in diameter and circular in form. Fortunately the left palate bone and soft palate were intact. The cicatrix had completely everted the lower lid and greatly depressed the cheek.

Figs. 396 and 397 show the face with the appliance removed and in place. The appliance is never out of the mouth longer than necessary. It is difficult and painful to replace it when it has been out a few hours.

There are two technic operations of interest in this case, taking the impression and stretching the cicatricial tissue.

The hole in the roof of the mouth was filled with slightly warmed yellow wax. This made the margin of the cavity quite tense. A plaster impression was obtained, the wax

Fig. 396

Fig. 397

removed from the hole and attached to the impression; from this a Spence plaster compound cast was obtained and a pure black vulcanite base-plate made. The denture was completed by the double vulcanization method. After the patient had become accustomed to the appliance and the mouth was free from soreness, resinous wax (sticky wax) was added to such portions of the obturator as necessary to distend and stretch the tissue in the desired direction. This was inserted into the mouth while the material was plastic, but not hot, then removed and chilled, another por-

tion added and chilled, until the tissues were distended as much as was prudent for the time. This was worn one night and the next day flasked in a box flask and the wax restoration replaced with pink rubber. This severe stretching invariably made the mouth quite sore, but the patient was very persevering and would not return to the office until the mouth was entirely healed. The patient was equally persevering in keeping the apparatus clean. This procedure was repeated probably ten times, once after these pictures were taken. The dark lines show additions made.

THE MITCHELL PALATE AND VOMER RESTORATION.[1]

"The object in presenting this subject is to show by actual demonstration the possibilities in the improvement of voice and speech, in the class of oral defects, by means of an artificial substitute for the missing tissues, and the advantage of such a procedure over surgical operations.

"Science has been unable as yet to solve the problem as to the causes. Many theories have been advanced, such as *faulty nutrition*, *heredity*, and *maternal impressions*.

"There are two reasons for attempting to correct this defect, either surgically or mechanically: First, the improvement of the general health; and second, the improvement of the voice and speech. Nature intended that we should have separate channels for the air we breathe and the food we eat. We know that this is so because of the difference in the anatomical formation of these cavities. Provisions are made in the nasal passages for the warming, moistening, and filtering of the air before it passes into the lungs. The oral cavity does not supply these requirements. On the other hand, the highly sensitive mucous linings of the nasal passages are most unsuitable for the passage of the different foods. In cleft-palate cases some food necessarily

[1] The following excerpts are kindly permitted by Dr. Vethake E. Mitchell, of New York City, and are from a paper read before the Oral Surgery Section of the First District Dental Society at the Academy of Medicine, March 25, 1913. The paper was published in full in the *Dental Digest*, October, 1913.

passes through a part of the nasal passages, and by constant irritation produces a catarrhal condition of these tissues, and secretes a viscid mucus which contaminates the air breathed and the food eaten by these patients. But this is not all: These unfortunates are conscious that their defect is announced whenever they attempt to speak. This has a deplorable effect upon their physical and mental development.

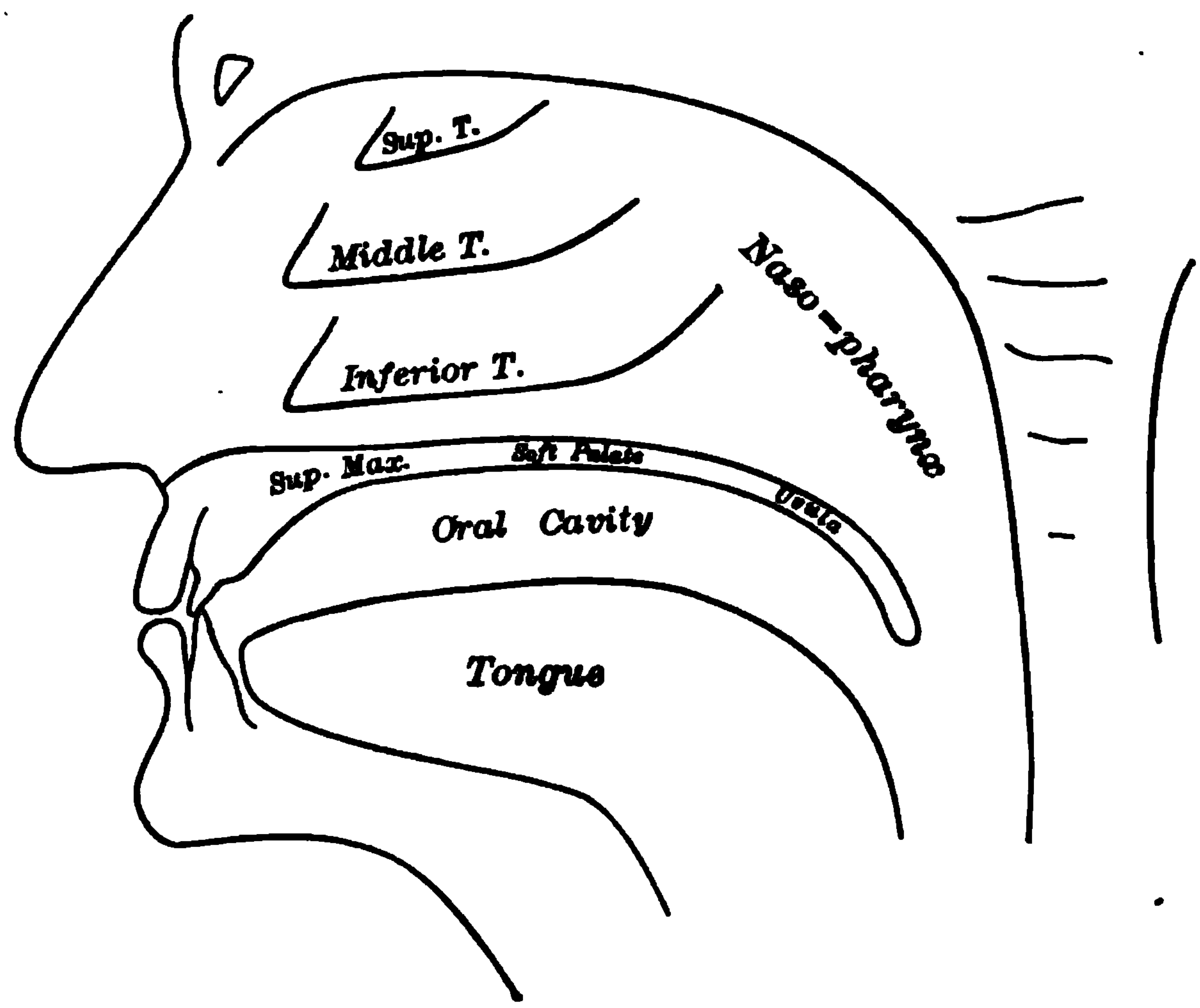

FIG. 398

"Secondly: The palate is one of the most important organs of speech. Its functions are concerned in the forming of the tone of the voice by regulating the shape and size of the resonance chambers, and to close off the nasal passages in the emission of certain sounds. This being impossible to a greater or lesser extent in cleft-palate cases, speech is very defective and gives it that peculiar quality which all can recognize.

"To understand more fully the tissues involved and their functions, let us refer to Figs. 398, 399 and 400.

"Fig. 398 shows the nasal cavities with the turbinated bones, superior, middle and inferior, on either side, each forming a resonance space, and when separated by the septum, with the hard palate beneath, forming six distinct resonance spaces.

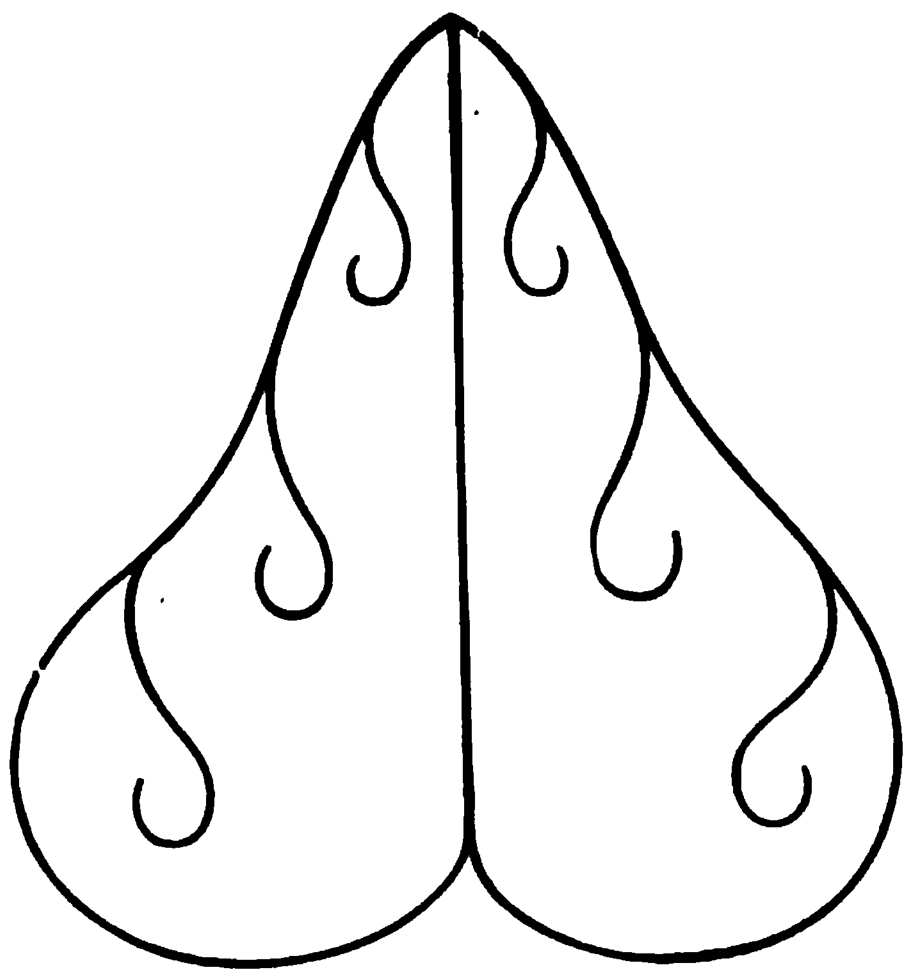

Fig. 399

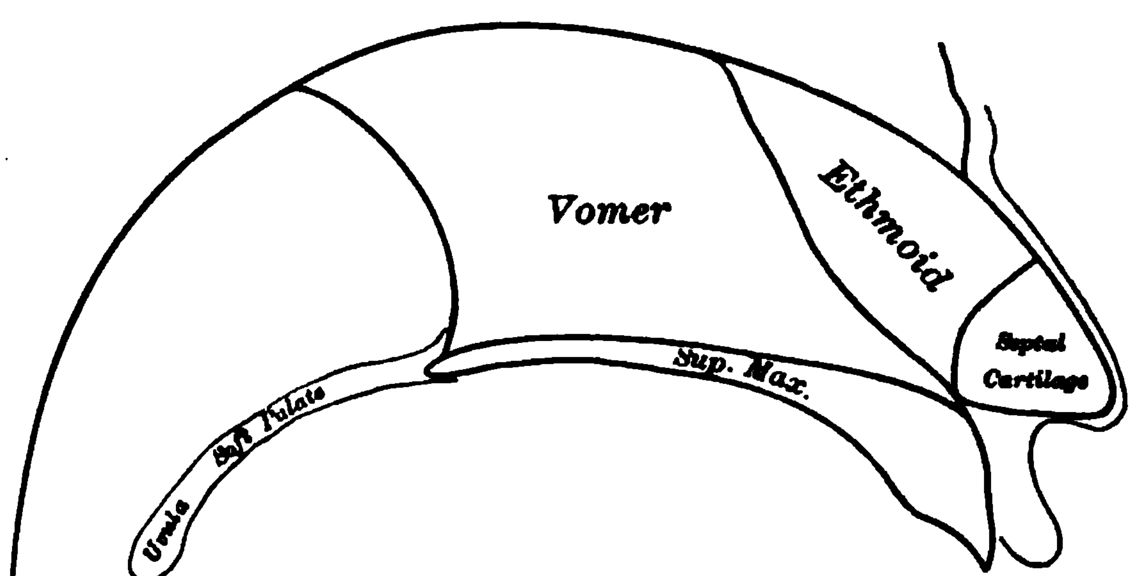

Fig. 400

"Fig. 399 shows these spaces better.

"Fig. 400 shows also the large nasopharynx, another resonance cavity, regulated as to size and shape principally

by the soft palate and uvula. Here can be seen also the oral cavity, still another resonator, with the tongue, soft palate, lips, and teeth—all concerned in the production of voice and speech.

"The cartilage of the septum (McClellan's *Regional Anatomy*) is a smooth, triangular plate inserted posteriorly into a groove in the perpendicular plate of the ethmoid bone: Anteriorly, where it is thicker, it is connected with the nasal bones and adjacent lateral cartilage, and below with the vomer and palatal processes of the superior maxillary bones. The septal cartilage separates the anterior portion of the nasal cavities. The inner wall is the smooth septum formed principally by the perpendicular plate of the ethmoid bone, the vomer bone, and the septal cartilage.

"Appliances of many shapes and of different materials have been devised for the closure of the cleft, but with apparently little regard for the restoration of the nasal passages, to permit normal respiration, or the restoration of the resonance chambers for the improvement of voice and speech.

"In the appliance which I present to you, all these things have been taken into consideration, and an attempt has been made to restore all missing tissues and their functions.

"The history of a case is as follows:

"Miss K——, aged thirty-one, second of four children. No deformity in any other member of the immediate family. Mother healthy, slightly tongue-tied. Father healthy. Her physical condition is good, but slight of build and undersized.

DESCRIPTION OF CLEFT.

"A division extends through the uvula, the soft and hard palates to the alveolar process. Width of cleft, at posterior border of hard palate $\frac{13}{16}$ inch. Vomer bone entirely missing.

"At nineteen an obturator was made and considerable improvement in speech resulted. This was worn for seven years, when a second obturator was constructed on the same style. This was worn for almost five years. The case was then referred to me to see what further improvement could be accomplished.

"A plaster impression of the mouth was taken in two sections, first by filling the posterior nasal cavity and cleft with plaster, to which had been added a little asbestos fiber, and allowing it to harden. This was easily removed by slight pressure directed backward, downward, and forward. That portion representing the roof of the mouth was prepared so as not to adhere to the second part of the impression, but with guides, so that the two parts could easily be fitted together. It was then returned to its position in the mouth and the second part of the impression taken in plaster, as an impression is taken in orthodontia. After hardening, all parts were removed, placed together in their proper relation, and a model made.

"A second impression and model are necessary for the swaging of the metal plate.

"Gold was used in this case, but silver or platinum could be used when advisable. It could also be constructed entirely of hard rubber, but for strength and thinness a metal plate is desirable.

"The cleft in the model is filled in, dies are made, and the plate swaged to cover the hard palate only. Clasps to go about the teeth are attached to the plate on either side, giving a firm attachment for the plate. To the nasal surface of the plate covering the cleft, four metal loops are soldered, for the attachment of the hard-rubber production of the lost bony tissue.

"With base-plate wax an artificial vomer was formed in the model. Its upper margin was closely adapted to the remnants of the septum. Its lower margin was adapted to the upper or nasal surface of the metal plate. This lower margin was spread out and thickened to replace the lost tissues of the hard palate. This was tried in the mouth to be sure of its close adaptation to the tissues.

"After imbedding in the wax at the posterior border that portion of the hinge intended for this part of the appliance, it was flasked and reproduced in hard rubber.

"The next step is to close the cleft in the soft palate with something that will stay in position and keep the cleft closed during the muscular movements of the palatal tissue. A

piece of base-plate wax was doubled and shaped to fit the cleft snugly from side to side. This forms the roof of the mouth and the floor of the nasal passages. It widens out as it extends backward, forming a flange on either side. This flange laps over the upper edges of the palatal tissue.

"The other part of the hinge is imbedded in the anterior portion of the piece which is to close the cleft in the soft palate. The piece for the soft palate is then attached to the plate by putting the pin through both parts of the hinge.

Fig. 401.—Model of the mouth.

The whole appliance in this stage is then placed in position in the mouth. By careful trimming or adding the wax of the soft-palate piece is given proper shape.

"It must extend back sufficiently and be so shaped that when raised by the muscles in the act of swallowing, it will touch the posterior wall of the pharynx so as to close the passage into the nasal cavity. This part is then reproduced in hard rubber, faced with pink, to more resemble the palatal tissues.

"Being solid, it has sufficient weight to keep it in position when the palate muscles are relaxed, and still is not too

heavy for them to raise when contracting. This movement is possible owing to the hinge joint. The whole appliance,

Fig. 402.—Mouth showing cleft.

Fig. 403.—Mouth with appliance in position.

Fig. 404

Fig. 405

Figs. 404 and 405.—Showing two views of appliance—lingual and side.

being constructed of metal and hard rubber, is perfectly hygienic and non-irritating to the tissues.

"While this appliance will help to restore normal function, education is necessary to improve speech, owing to the fact that the patient being unable to make sounds in the normal way through the lack of these parts, it has been necessary for her to bring to her aid other tissues or parts in the attempt to produce the various sounds. Thus habits have been formed which it is necessary and hard to overcome; but with this appliance and the coöperation and persistence of the patient these difficulties can be overcome.

DEMONSTRATION.

"Miss K——'s appliance, as you see, is constructed as I have described (shows appliance). *Without the aid of her appliance* I shall ask her to pronounce some of the most difficult letters of the alphabet.

"First, the labials—B P F V.

"The anterior lingual palatals—C D S T.

"The posterior lingual palatals—G K Q and X Y Z.

"Now an awkward combination, such as "sixty-six."

"And a still harder combination, the name of Dr. Norman W. Kingsley. *With her appliance in the mouth* she will repeat this combination, which I think will demonstrate to you a very marked change in the quality of her voice, her articulation and enunciation. (*Miss K—— repeats the above.*)

"To show that when the palate is raised by the muscles the nasal passages are closed, and the breath may be forcibly expelled through the mouth, I shall ask Miss K—— to blow out the candle. This may seem a very simple matter, but I assure you that she was not able to do this before the introduction of this appliance, and now you see she is a pretty good *blower!*

"Most appliances that are constructed at the present time are bulbous, or of the plug type, which necessarily interfere with the nasal resonance, the appliance more or less filling up these resonance cavities. To show how absolutely important it is to have the nasal passage restored to as nearly as possible a normal condition, I shall add a piece of wax to either side of the vomer bone (of the appli-

ance), completely closing off the nasal passages, showing the interference of nasal resonance.

"To demonstrate this Miss K—— will say: *Nae*, *Nah*, *Noh* and *Ing*, *N*, *M* with and without the obstruction.

"Now to see what is possible with the singing voice, we will be assisted by Miss K——'s vocal teacher.

"Through the development of her breath control, and by a unique *card buzzing exercise* used in Vocal Art Science, to dėvelop certain phases of the voice, she is now able to blow a steady flow of breath through the lips, and she will open her singing demonstration by a little exercise in card buzzing, to show breath control.

"Next, the scale of thirteen vowels and thirteen consonants will be used. These scales have been arranged so discriminately in their sequence in "Vocal Art Science" that by their correct use each and every resonator from the tip of the nose to the epiglottis is exercised, and finally all are correlated.

"With the use of the scale of consonants and vowels all muscles for articulation and enunciation, namely, the lips, tongue and palate, are exercised and developed, and perfect *pronunciation* is the result.

"Miss K—— will demonstrate the above combination: first, to show her breath control and tone quality, she will sustain the thirteen vowels at three or four different pitches.

"Then, to show *her* use of the scale of thirteen consonants and vowels she will sing them on chromatic scales, and reverse the order on descending. (*Miss K—— sings scales of thirteen vowels and consonants.*)

"To demonstrate the practical use of the mechanical appliance on showing the foremost and highest nasal resonance, she will sustain the combination of *Ing*, *N*, *M*, and will prolong the sound of *M* to show its position in the singing quality. (*Miss K—— sings Ing, N, M.*)

"To demonstrate the perfect mechanical action of the appliance she will sing an arpeggio that moves from a lower to a higher pitch in the ascension. This necessitates a rise and fall of the normal palate and is perfectly apparent with the artificial palate. (*Sings arpeggios.*)

"Miss K—— will finish her demonstration by singing two ballads. This is to show the combination of articulation, enunciation, pronunciation, and also the legato in singing. The latter necessitates perfect breath resistance against the upper incisors, which again is made possible by the mechanical appliance.

"Let me state in conclusion that Miss K——, in the training of her singing voice, and perfecting of her articulation and enunciation, has had only twenty lessons thus far. (*Miss K—— sings two songs.*)

"Dr. E. A. Bogue said, in discussing Dr. Mitchell's paper, that it was well known to some of the profession that he came to New York originally to take charge of the practice of Dr. Norman W. Kingsley. This, Dr. Bogue said, had caused him to become acquainted with quite a number of gentlemen who had busied themselves in the manufacture of artificial vela, but that he had never seen so strikingly good a result."

REFERENCE BOOKS.—Kingsley's *Oral Deformities, American System of Dentistry, American Text-book of Prosthetic Dentistry,* and Case's *Orthopedic Dentistry.*

CHAPTER XVI.

ESTHETICS.

For the purpose of establishing a clear idea of what we mean by "esthetics of prosthesis," we define the term "prosthesis" as: The science, art, and esthetics of restoring a lost dental organ or organs and associate parts with an artificial substitute.

To understand this subject we must have well-conceived ideas of the three terms, science, art, and esthetics. Science is classified knowledge; therefore it is the involved theory. Art is a complex term; primarily it means doing a thing in a skilful manner; thus it is used to express perfection in any oft-repeated mechanical work, as the manual labor in any of the useful trades, useful arts and crafts; and to the working out of beautiful thoughts in concrete form, fine arts. As esthetics expresses the latter idea, we incorporate in our definition the two terms, *art* and *esthetics*. Art, to express the skilful doing of mechanical work, and esthetics, to express the harmonizing of our creation with its environment, or, the art of concealing art. Thus, when we mean the skilful construction of mechanical appliances, we shall speak of art, artistic, and artisan; but when we mean that which is more than mechanical art, the ideal, the beautiful, because harmonious, then we shall speak of the esthetic and esthetist or artist.

Is prosthetic dentistry a trade or a profession? This depends entirely upon how it is practised. The science involved is not a factor in determining whether prosthesis as practised is a trade or a profession; for both the useful and fine arts may be highly scientific. If prosthesis is practised as a utilitarian art, then it is, and can only be, a trade; but if the utilitarian art is dominated by esthetics,

then and only then can it justly be called a profession. The *Standard Dictionary* defines a profession as: "An occupation that properly involves a liberal education or its equivalent, and mental rather than manual labor." Hunter's *Encyclopedic Dictionary* defines a profession as: "A business which one professes to understand and to practise for subsistance; a calling, occupation, or vocation, superior to a trade or handicraft." Is it not conclusive that a commercial dental laboratory is practising "mechanical dentistry" only? In order to practise prosthesis (Greek, *pros*, to; *tithemi*, place, to place or restore) it is necessary that the patient shall be under the inspection and study of the prosthetist so as to restore the contour and harmonize the associated parts. If one is to practise prosthesis as a profession, he must be more than an artisan; he must be an artist. It is a common saying that artists are born and not made. This saying, like most of its kind, is only in part true. However, we can say there are but two sources from which artists may be produced, namely, made and born, cultivation and intuition. The idea of an artist being cultivated is in keeping with the *Standard Dictionary* definition of a profession that is: "A liberal education or its equivalent, and mental rather than manual labor." The artist must have, in addition to the manual dexterity of the artisan, the developed mentality and imagination that can create ideas and ideals, and then, with his artisan dexterity, he puts his ideals into concrete form. Thus, he makes of his useful art a fine art; and he becomes an esthetist, an artist, and his calling is a profession. Therefore if one would be an esthetic prosthetist, he must develop himself and broaden his art. The remaining source from which artists are produced, that is, born, or, as we classified the idea—intuition—is an unknown quantity and of uncertain value. However, for a dentist to depend upon intuition for producing esthetic work would be like a preacher depending upon inspiration for his sermon; too often the product would only be perspiration. True it is that some people seem to have more natural ability than others; but it is more than probable that much of this seeming inherent or intuitive ability is the result of early

cultivation in ways that have contributed to the final product.

There are two attributes of a man that are necessary for success in any line, namely, desire and energy. Desire and energy is the celestial fire which will, when sufficiently strong accomplish everything. Longfellow has well expressed the thought in this stanza:

> "All the means of action—
> The shapeless masses, the materials—
> Lie everywhere about us. What we need
> Is the celestial fire to change the flint
> Into transparent crystals, bright and clear.
> That fire is genius."

Someone has said that "Genius is infinite capacity for painstaking." Thus, we must conclude that if a dentist does not succeed in reaching high attainments, the celestial fire within him is passive and not active: or, that his energies have not been well directed.

Thus far we have endeavored to establish what is esthetics of prosthesis, and present the conclusion that it is applied, refined ideals of prosthesis, developed by earnest desire and well-directed energy.

Dr. Charles Channing Allen has well expressed the relation of esthetics to dentistry in a paper read before the Kansas State Dental Association, May, 1908:

"When a work is executed with the concepts of beauty, utility, and economy in their proper proportions, that work has its own individual characteristic, the evidence of design. This is its passport; its credential; its hall mark; its justification. In such character it shows whether it is the legitimate child of orderly intelligence, or the bastard of bungling incompetency. If it was fathered by an understanding of the requirements and a skill sufficient for their execution, then it must appeal to the mind as answering the requirements of esthetics—the beautiful. . . . Although in giving consideration to design over mere beauty we cannot accept the dictum that beauty is without definite utility. Beauty carries with it more of the evidence of design than mere utility, for the esthetic or beautiful appeals to one

immediately, and does not require a systematic proof along the recognized lines of logic, but establishes itself in the mind of the beholder at once without proof. Utility alone, as an ultimate end, executed without embellishment, may be, and usually is, vague in expressing its reason for existence, and must be studied and its purpose analized, often laboriously at tiresome length.

"No profession has more use for the esthetic and beautiful than the profession of dentistry; for an esthetic restoration is a very important part of our obligation to our patient."

We assume that the Creator designed that every soul should inhabit a perfect body. According to its type, it should be like the Greek creation Apollo, every line and every inch god-like in its perfection. Had the original design prevailed, there could have been no beauty associated with the human form, because there would have been but one type, and each individual would have been a duplicate of all others. Beauty is appreciated by contrast only. The Creator also gave the laws of environment. Therefore we have not two persons that are exact duplicates of each other. As the body is molded and shaped by external mental and physical influences through conception and gestation, and by both external and internal mental and physical influences through infancy, youth, adult, and senility, there can be no perfect duplicate or absolute conformity to a given standard; and yet, how wonderfully alike are human beings.

Ethnologists, physiognomists, and other scientists have divided and subdivided the human family into many classes for the purpose of better studying man. So far as prosthetists are concerned, our studies have been confined almost entirely to the Caucasian race, and we consider only such classification as will aid us in understanding the needs of the profession. We first divided the race into classes—light (blonde) and dark (brunette)—a simple classification easily understood, and which call attention to certain facts.

Another classification we may call the "dental profile" classification. Scientists consider this subject as a study of the facial angle, and make two general divisions—orthog-

nathous and prognathous. This division is of little value to the dentist, yet the study of the profile is perhaps the most important of all the classifications for the prosthetist.

A third classification to be considered is that of the temperaments.

DENTAL PROFILE.

For convenience, we divide the dental profile into three classes—*straight* profile, *convex* profile, and *concave* profile.

Scientists in drawing the perpendicular line of the face have it touch the most prominent point in the median line of the forehead and the most advanced portion of the maxillæ. The dental profile line is somewhat different from the perpendicular facial angle line.

The first class, or straight profile, is the Greek ideal face. The perpendicular line has three points of contact—the frontal and mental eminences, and the middle of the wing of the nose. The lower lip will just touch the perpendicular line, and the upper lip will be a little in advance of the line. There is no question that this is the normal profile of the highest ideal of beauty.

The second class, or convex profile, has two points of contact with the perpendicular line—the frontal eminence and a point at the base of the nose which is the same distance from the middle of the back of the ear as the frontal eminence. In the type, this point will be the center of the wing of the nose.

The ideal standard of this class has the face made up of rounded, graceful curves; forehead high and slightly receding, nose of Greek or Roman type; lips full but not coarse; chin receding but not weak; teeth, both number and alignment normal. No competent orthodontist would think of converting this ideal of our second class into the first or straight class, for he would recognize that the harmony of the features would be destroyed.

The third class, or concave profile, has the frontal and mental eminences only in contact with the perpendicular line. It is not possible to conceive of this profile being a mark of beauty, and it is fortunate that the class is small

compared with the other two. It is a condition confronting the prosthetist, and he must place the features in as pleasing a relation to the concave line of the individual as possible.

The physiognomy of man is gradually changing and tending toward types. The intermarriage of different nationalities and the modes of living, causing mental development and physical degeneracy, partly account for this condition. For the last few years orthodontists have been impressing upon our attention the importance of teeth in the physiognomy of man, and giving us a rational reason for many of the abnormal conditions. This same study is of value to the prosthetist, as it aids him to understand the design of nature for the individual case; also aids him in classification. In studying the harmonies and inharmonies of the face, it is important that we consider the causes as well as the effects.

When the prosthetist has studied the individual case and classified it he is confronted with the question, What is one's duty, to restore the features to the natural or to the normal condition? It is apparent that a normal convex profile should not, in a portion of its outline, be converted into the concave type, thus forming an ogee monstrosity. *Each individual case must be kept within its normal class,* then it is a matter of judgment for the prosthetist and patient to *decide to what extent* the natural peculiarities shall be modified.

It should be borne in mind that physiognomists make a distinction between anatomy and expression. Expression is of the soul, by and through the anatomy. Therefore deformities of the anatomy may belie the soul. The prosthetist should study well to have the teeth of the proper size, color, form, arrangement, and the dentures so contoured that they may harmonize with the rest of the anatomy of the face. The esthetics of prosthesis may be expressed thus: Harmonious in anatomy and pleasing in expression.

Fig. 406 is the classic figure Apollo, and is the Greek type of the straight profile. For study purposes and as an ideal, artists have divided the face into three parts called

thirds—upper, middle, and lower (see Fig. 1). The ideal face has the three-thirds of equal length, but in actual life they rarely attain this relationship. Also the ideal head has the ear entirely in the middle third, and of the same length as the nose.

Fig. 407[1] is a fair representation of life, that is, that faces are not formed by rule. However, it is necessary to have a standard for comparison, that ideas may be conveyed from one to another. Therein is the only value attached to the Apollo in dental study. Referring to Fig. 407 it is seen that

FIG. 406

the upper and middle thirds are equal in length, but that the lower third is very much longer. The upper two-thirds belong to a square type of face while the lower third belongs to the parallelogram (see Fig. 419). It is also seen that the ear does not harmonize with the middle third but does with the lower third of the face, therefore the face is a blend of two types. The square type predominates, as it is two-thirds square; therefore to have a perfectly harmonious face it

[1] The well-known late Dr. J. W. Greene, who probably has done more toward developing impression taking than any other one man.

would be necessary to remodel the lower third and the ear to conform to the upper two-thirds. It is sometimes stated in association discussions that the length of the nose determines the length of artificial teeth because the lower third when the mouth is closed should be of the same length as the middle third of the face. In this individual case if the natural teeth were all lost it would be impossible to construct dentures with a sufficiently close-shut bite to reduce the lower third to the dimensions necessary to make the face three-thirds square type. Nevertheless to restore the mouth with teeth

Fig. 407

of the length of tooth and bite of youth would be wrong for two reasons: (1) esthetics require that the teeth should be well aged, that is, much shortened by wear and (2) the *natural* conditions should be modified toward the *normal*, thereby producing a more harmonious relation of the three portions of the face.

Figs. 408, 409 and 410[1] are respectively straight, convex, and concave profiles. In all three of the illustrations each

[1] Figs. 408 and 409 were taken from public prints and are of persons notable for mentality and humanitarianism; Fig. 410 is of a drawing by Lavater depicting melancholia. It makes emphatic the prominence of the frontal and mental eminences and the depression of the maxillæ.

third is in harmony with the remaining two-thirds of the face. A study of the profile consists of a comparison of the thirds of the face. Very often the lower third will not be in harmony with the facial type. It is in this class of cases that the prosthetist and orthodontist may improve upon the natural; that is, they may mold the lower third of the face

Fig. 408

Fig. 409

Fig. 410

toward the normal of its predominating type. The straight profile seems to predominate in the German, French, and Celtic types, while the convex profile is specially prevalent in the English, Scotch, and Jewish types.

Fig. 411 is Dr. B. J. Cigrand's selection of three historical characters as representative of the three profiles. The lower

two-thirds of the face of Daniel Webster is of the straight profile, while the massive development of the frontal eminence would place the upper third with the concave class. The face of Cardinal Newman is equally fine, but the frontal and mental eminences are overdeveloped, thereby giving the concave profile. Henry Clay is a fine illustration of the convex profile. However, the lips are a trifle flat.

Fig. 411

Figs. 412 and 413 are taken from Angle's work on *Orthodontia.* This profile is also a mixed one. The upper third is a fine illustration of the straight profile. The middle third would require a careful study of the face to determine its classification. The cast of the upper dental arch (Fig. 412) shows an almost ideal alignment and complement of teeth; however, the apparent depression in the proximity of the apical ends of the teeth, also the concave form of the nose, would indicate an insufficient development of the upper portion of the maxilla. This factor would require careful inspection to determine whether this seeming depression is real or only apparent because of the greatly enlarged mandible. If the upper portion of the maxilla is fully developed, then the face belongs to the straight profile

type, complicated with a greatly malformed mandible; if the upper portion of the maxilla is depressed, then the profile is of a mixed type; the lower two-thirds, being complicated with an enlarged mandible, is of the concave type, and the upper of the straight type.

FIG. 412

FIG. 413

Lips.—There is one other factor in the study of the profile that must always be given careful attention when making restoration with artificial dentures, and that is the lips. The lips may be classed as thin, medium, and thick; also one may be thin and the other thick. The proper contouring of the lips can only be done by the proper setting of the anterior teeth, and the contiguous gum restoration. This factor is not a part of anatomical occlusion, which is purely mechanical and scientific; but is of the esthetic and can be produced only by the one seeing and handling the mouth. Therefore a dentist who is satisfied with the mounting of artificial teeth by a commercial dental laboratory shows himself deficient in the esthetic sense, and owes it to himself and his patient to either develop the esthetics of prosthesis or eschew prosthetic dentistry. The writer trusts this condemnation of a very considerable portion of the dental profession will discourage no one, but will excite many to a sense of duty and an earnest effort at perfecting himself.

The proper contouring of the lips may require that the anterior teeth may have end-to-end occlusion, or that there may be little or much protrusion of the lower anterior teeth; or they may require little or much retrusion. The setting of the six upper and lower anterior teeth with the amount and shaping of the contiguous gum restoration has more to do with the beauty of the face than the proper selection of teeth, because the contour of the lips is visible at all times, and the teeth only when speaking and laughing. However, perfection implies that no part is deficient, therefore equal attention should be given to every factor and the teeth selected of suitable form, size, color, and texture, the teeth occluded anatomically, and the lips restored so that the lower third of the face may harmonize in anatomy and be pleasing in expression.

HARMONY.

The preceding chapters of this book have been devoted to developing the mechanical phases of prosthesis, also a reasonable science for the modes of procedure, and incidentally the cosmetics have been touched upon. However, in teaching the science and art of prosthesis it is not wise to more than intimate the existence of the esthetic, because of the confusion and distraction of mind created. The prosthetist must first become an artisan, and then, with patient endeavor, develop the artist. The utilitarian art is the first consideration, and is that for which there is the greatest demand; but for the mechanical dentist to dignify his work and make himself worthy to be ranked as a professional man he must place the stamp of ideality upon the product of his hand. As there are no two individuals exactly alike, in fact no individual, one side of whose face is the counterpart of the other, it is impossible to establish fast rules for esthetics. It is possible, however, and is the province of this chapter to map out certain lines of thought, and some technic as a means for harmonizing the work of the craftsman with the environment and making pleasing the expression of the individual. To recapitulate: The

finishing touches of the artist shall conceal the work of the artisan. As the sculptor and painter may only express their thoughts in tangible substance, so it is that the dental esthetist may only express his thoughts by means of the artificial denture. The value, therefore, of the prosthetist's creation is not in the intrinsic value of the physical material entering into it, but in the quality and quantity of thought expressed in the artificial substitute. The science and art of prosthesis deal with the materials and manipulation of them, whereas esthetics has to do with contour and color regardless of the material used. Contour and color are concerned with the surface only; therefore the lingual, labial, and buccal surfaces are the subjects for our further consideration of artificial dentures.

Lingual Surface.—The lingual surface of the maxilla is dome-shaped, but varies in conformation from an inverted V (Λ) to a flat surface. As the dome of the mouth is one of the resonant chambers, useful in articulate speech, it is evident that its form has much influence in sound formation. This does not imply that a definite shape of the vault is necessary to articulation, but it does imply that certain conformations are more favorable for clear enunciation than others, and that clear enunciation cannot be had with every vault formation. Therefore the prosthetist may mar or improve the conditions for good enunciation. The rounded oval dome vault is the best devised for human speech. However, the genius of mankind is great, and he can overcome many of the impediments to sound formation. Nevertheless, when he has required the art of enunciation, any radical change in this resonant chamber will necessitate a change in the manner in which the tongue is conformed and placed. Therefore it is logical to assume that the conformation of the lingual surface of the artificial denture should be as near the size and conformation of the vault in which the subject has acquired good enunciation as possible; otherwise the individual will have to learn the art of clear speech over again. Chapter I, in connection with Figs. 13, 14 and 15, illustrate the changes that take place due to the loss of the teeth. Fig. 13 demonstrates that any unnecessary thickness

of the lingual surface of the denture is an impediment to speech; however, as a mechanical appliance is essential to restore the lost tissues, good mechanics requires that the apparatus shall have a safe margin of resistance to the stress to which it may be subjected. This will require a thickness of material in the indirect ratio to the strength, rigidity, and elasticity of the material employed. Is it not evident that the carving of the lingual contour of the teeth, gums, and rugæ, as seen in many of the illustrations of this book, are more than fanciful, that it is the acme of the practical in restoring enunciation? Further than this, the restoring of the rugæ is beneficial as an aid to the tongue in deglutition. Chapter I should be read as a further elucidation of this theme. The technic of restoring the lingual surface consists of the methods previously described and illustrated. The requirements of esthetics are that the original contour of the lingual surface of the maxilla shall be reproduced as nearly as possible; that excessive thickness of the linguocervical portion should be employed only when other conditions make them imperative.

Labial Surface.—The labial surface may be defined as that depicted by the incisor and cuspid teeth. The contour of this surface of the artificial dentures is to give support and form to the overlying soft tissues, thus restoring the anatomical harmony and aiding in the expression. There are two portions of this surface to be considered, namely, the gum portion and the teeth. Chapter I describes the change wrought by resorption of the alveolar processes, and the same chapter explains the muscles and their action associated with this surface of an artificial denture.

The contour of the gum portion requires that it shall not impinge upon the frenum labii, nor make too full the incisal fossæ; but that it shall restore the cuspid eminences, including the nasobuccolabial triangles. As previously suggested, the contour for the individual case will be determined by the typal condition. The contour of the teeth will be influenced by the type and age of the patient. In order to understand the typal influences it is necessary to digress from the theme of study and consider abstractly the temperaments.

TEMPERAMENTS.

Dr. Jacques defines temperament as: A state of the body depending upon certain combinations of the various systems and organs and certain functional conditions affecting them.

The temperaments are physiological conditions and are usually considered unchangable. Dr. Jacques, than whom there is probably no greater authority, states, on page 110 of his book, *The Temperaments*, that:

"When once established, the temperament inclines naturally to perpetuate and increase itself, since it gives rise to habits that exercise the organs on which it depends. A change of temperament, then, implies strong counteracting influences brought to bear upon the constitution; and as such strong influences are in a majority of cases lacking, the inherited tendency is generally followed, and a temperament once established is maintained through life. This, however, is far from being universally the case. The inherent predisposition is sometimes entirely overcome and the constitution radically changed."

There are various classifications of the temperaments; but the one here used (because it is the one associated with the classification of teeth) is the one apparently adopted and described by Dr. Spurzheim.

"1. **The Lymphatic Temperament.** — The lymphatic or phlegmatic temperament is indicated by pale white skin, fair hair, roundness of form, and repletion of the cellular tissue. The flesh is soft, the vital actions are languid, the pulse is feeble; all indicate slowness and weakness in the vegetative, affective, and intellectual functions.

"2. **The Sanguine Temperament.**—The sanguine temperament is proclaimed by a tolerable consistency of flesh, moderate plumpness of parts, light or chestnut hair, blue eyes, great activity of the arterial system, a strong, full and frequent pulse, and an animated countenance. Persons thus constituted are easily affected by external impressions, and possess greater energy than those of the former temperament.

"3. **The Bilious Temperament.**—The bilious temperament is characterized by black hair; a dark, yellowish, or brown skin; black eyes; moderately full, but firm muscles, and harshly expressed forms. Those endowed with this constitution have a strongly marked and decided expression of countenance; they manifest great general activity and functional energy.

"4. **The Nervous Temperment.**—The external signs of the nervous temperament are fine, thin hair, delicate health, general emaciation, and smallness of the muscles, rapidity in the muscular actions, vivacity in the sensations. The nervous system of individuals so constituted preponderates extremely and they exhibit great nervous sensibility."

These four divisions are spoken of as primary temperaments. It would be exceedingly difficult to find an individual whose organization complied with any one of these divisions only. Most persons show one temperament markedly strong, but modified with one or more of the other temperaments; while others possess an equal blending of two or more temperaments. It is this blending of the classes in varying degrees that causes the difference in the physiognomy of persons and peoples. However, to study the complex it is necessary to reduce it to its components; therefore the temperaments are first studied in the primary classification, as lymphatic, sanguine, bilious, and nervous; and then in the binary classification, as lymphatosanguine, and sanguolymphatic, the one being the basic and the other the modifying temperament. Unfortunately, writers are not agreed in the manner of forming the compound noun. Some writers first name the basic and then the modifier, as sanguonervous; others reverse the order, as nervosanguine, both referring to the same physiognomical condition. Because of this confusion of nomenclature the writer prefers using a phrase in place of the compound noun, as the sanguine modified with the nervous temperament, or the nervous modified by the sanguine temperament. The meaning is then unmistakable.

Dr. Jacques states that it is very difficult to get portraits representing the lymphatic temperament, but that the

illustrations he gives show its general tendency. Figs. 414 and 415 are reproductions of two of his examples. The one

Fig. 414

Fig. 415

Fig. 416

to the left is modified with the bilious temperament, while the one to the right is modified by the sanguine temperament.

Figs. 416, 417 and 418 are reproductions of his examples of the sanguine, bilious, and nervous temperaments consecutively.

Fig. 417

Fig. 418

Professor Prothero, of the Northwestern University Dental School, in his book, *Prosthetic Dentistry*, presents a condensed table of the primary temperaments and their appropriate teeth. The table here reproduced will aid in fixing in the mind the main facts pertaining to the temperaments and their application to the selection of teeth for an edentulous patient.

	Basal temperaments.	Eyes.	Hair.	Teeth.	
				Color.	Shape.
Classification of temperaments	Lymphatic	Pale blue or gray	Fine and silky, but without luster	Pallid, opaque, or muddy yellow	Poorly shaped, broad and flat.
	Sanguine	Blue, brilliant, and expressive	Blond-red or chestnut, seldom dark or black	Cream-yellow, darker at neck	Well proportioned, curved and rounded.
	Nervous	Light gray or blue, restless, often morbidly brilliant	Fine, light, and soft	Pearl-gray, or blue tinge	Long, conical, and rounded
	Bilious	Black or brown, small and piercing	Coarse, dark, often black, and abundant	Strong, bronze yellow	Conical, long, and angular.

There is but one object for the dentist studying the temperaments, and that is to aid in selecting teeth of suitable form and color. It is true that the classification of temperament is not based upon scientific facts, but nevertheless certain facts have been grafted onto the pseudoscience, and if the familiar terms are used only to define certain combinations of form and color no harm is done.

Madame Schimmelpennick, an English authoress, issued a work in 1815 on the *Science of Beauty*, from which Fig. 418 is taken. This reduces the fundamental forms of faces to the square, triangle, and circle, with modifications.

The form of the central incisor being obtained by the shape of the face was given in a paper and by demonstration by Dr. F. H. Berry, of Milwaukee, Wisconsin, at Buffalo, New York, at the annual session of the Institute of Dental Pedagogics, 1903.

Dr. J. Leon Williams uses the same geometrical figures to express the forms of teeth. Recently his writings have appeared in several publications, notably the *Dental Digest* beginning with the February 1914 number.

Fig. 419

The forms of teeth suitable for the patient having been determined, the size and color remain. The size of the teeth is determined by instruction given under the heading Grinding and Setting Up on page 252.

Color.—There are but two primary colors that need be considered in the color of teeth, yellow and blue. These two colors are found in all teeth in varying shades. The brunette will have the yellow of a bronze hue, while the blonde will have the yellow of a creamy hue. Blue is in the teeth mostly as gray, and its intensity will be in the ratio

to the intensity of the color of the skin. The teeth histologically are of the dermal tissues and derive their color from the circulating fluids of the body, but with this difference, that with advancing age the dermal tissues, with the exception of the teeth, lose their intensity, while the teeth increase in intensity of color.

Elaborate descriptions and extensive classifications of the temperaments may be found in both the *American System of Dentistry* and the *American Text-book of Prosthetic Dentistry*. The student is referred to these works for a further investigation of this subject.

APPLICATION.

Returning to the theme, *labial surface*, it remains to apply the ideas presented under the headings Profile and Temperaments. This may best be done by use of a patient. The patient (Figs. 420 and 421) has been edentulous for many years. She is about sixty years of age, strongly sanguine, with a nervous temperament modification. The sanguine temperament is indicated by the generally rounded cast of features and physique of the blonde type. The nervous temperament is indicated by the width of the forehead and by the toning down of the blonde type of coloring.

Figs. 422 and 423 present the patient wearing artificial dentures that do not restore the harmony of the face, therefore causing her to appear more aged than she is. Notice the straight profile, which should be slightly convex, the exaggerated lines about the mouth, the compressed lips, and the depressed nasobuccolabial triangle. Compare this with Figs. 424 and 425, in which the features have been restored so that the lips in profile are slightly protruding, the exposed mucous membrane is natural and in keeping with the thickness of the lips. Observe the gradation from the thin, compressed, severe, and repelling expressions of the edentulous mouth, to that of the serious, but cheery and pleasing expression of the restoration. Surely the dentist's handiwork may belie the soul, or it may be in harmony with that of the Creator and Father Time.

Fig. 420

Fig. 421

FIG. 422

FIG. 423

Fig. 424

Fig. 425

Occlusion and Contour Models.—Chapter IV instructs how to form the occlusion models, but necessarily the contouring of the models could not, at that time, be discussed. Now, in the study of the esthetics of restoration, the required contours of the wax models should suggest themselves to the mind of the student, and he should see that a half-hour or even an hour spent in modelling the contour models is time well and profitably spent. Fig. 70 shows the wax

Fig. 426

models with the median portion and the incisive fossæ depressed, and the cuspid eminence represented. The occlusal border of the upper model overlaps the lower; and the lower model is depressed horizontally to represent the sulcus mentolabialis of the external surface of the lower lip. While the occlusion and contour models represented in Fig. 70 were not for this patient, their conformation is very similar to that which was required. However, Figs. 244, 245 and 246

are of the denture in the mouth of the patient shown in Figs. 424 and 425.

Technic of Model Contour.—The wax models, having been constructed for occlusion, are placed in the mouth and,

Fig. 427

with the face in repose, studied for contour. The face is studied in profile and in full front, while the portion of the wax models to be added to or taken from is determined by gentle pressure of the fingers upon the external surface of the lips. While conducting this contour modelling of the

Fig. 428

labial surface of the wax models the prosthetist must be certain that the mandible is in retrusion. The anatomy of the parts to be considered in the model restorations are described in Chapter I. It is unnecessary to develop per-

fection of restoration in the wax models, for the final esthetic restoration is to be wrought in the model dentures; that is, with the porcelain teeth mounted on wax. Little attention need be given at this time to the linea nasolabialis, nor need the patient be shown the restoration; indeed, it is not well to call attention to this phase of the construction, because the work is only blocked out and a trained imagination is required to comprehend the result, which attribute the average patient does not possess.

FIG. 429

Buccal Surface.—This surface need not be considered in the occlusion models from the view-point of contour, but it needs careful consideration at the time of proving the occlusion and contour of the model dentures. The patient shown in Figs. 424 and 425 requires no buccal restoration, and this is true of probably a majority of patients.

Fig. 426 is a profile view of a patient requiring extensive restoration. Figs. 427 and 428 give two views of the required artificial dentures as first developed in the models and then reproduced in vulcanite. Figs. 429 and 430 give two views of the features restored. The buccal contours do more than reduce the excessive dimples of the cheeks; they modulate the linea nasolabialis, and in such a way that the line is flexible and graceful both in repose and action. If the cuspid fossæ are built out in the artificial denture for

Fig. 430

the purpose of obliterating these lines in repose, it will produce an exceedingly disagreeable effect when the mouth is in action.

EXPRESSION IN ACTION.

If the face were always in repose the study of esthetics would be finished, but the severest test of the esthetic creation is when the patient is speaking and laughing; for

then the size, form, color, arrangement, and individualized effect of the teeth are on exhibition, and if the prosthetist has concealed the art, he is an esthetist, and need not be ashamed of his handiwork.

TEETH.

Size.—The size of the teeth were considered in the technic of construction (Chapters I and VI).

Form and Color.—The form and color of the teeth are determined by the class or temperament when the patient is edentulous, but are selected to harmonize with the remaining teeth in partial cases.

Arrangement.—The teeth are arranged as instructed in Chapter VI, modified slightly so as to conform to the individual indications of the patient; that is, the lymphatic type will require the arrangement to be a trifle flatter and broader than described in the mechanical setting up of the teeth. The sanguine type will require no change in the six anterior teeth, but the bicuspids should be slightly more prominent. The bilious type will require the central incisors to be depressed so as to give a square effect, but no change distal to the cuspids. The nervous type may have the centrals more prominent and the cuspids slightly depressed.

Individualization.—Here no rule can be established, for it is the little touches, here and there, by way of slightly rotating, inclining, protruding, retruding, extruding, or intruding one or more of the teeth; also grinding, inserting fillings, and staining the teeth that completes the harmony. This work should be done by the aid and with the approval of the patient, and possibly a friend. It is often wise to lead the patient or friend so that they will suggest the desired change. However, this does not imply that inartistic and monstrous desires of some patients are to be complied with; not at all, but if the patient can be led to suggest what is really needed, it will usually be more readily accepted. This will prove a good suggestion if properly used. Nevertheless, there are many patients that have little artistic sense, and cannot be asked to aid in this important task. Unfortunately these are the persons who are later subject to the influence of incompetent critics.

Gold Fillings.—Gold fillings may at times be inserted so as to greatly relieve the artificial effect, especially when the patient has had, for years, conspicuously displayed gold fillings. In such cases it is well to reduce the size and number of the fillings and place them so as to give the appearance that the patient has gone to a more esthetic practitioner. Gold crowns for display purposes should never be tolerated unless the patient is markedly "loud" and nothing less will complete the harmony.

Technic.—The tooth to be filled is cupped out with a small stone, so as to form a saucer-shaped cavity; dove-tailed grooves may be cut with a small knife-edged disk stone, and retaining pits made with a diamond drill kept wet with water. The tooth may be mounted with sealing wax on a block of wood, as a means of support while filling with gold. This mounting may be done before preparing the cavity, but preferably after the cavity is cut.

STAINING THE TEETH.

The manufacturers of artificial teeth are to be commended for the excellence of their product, but such stock cannot be individualized at the factory. The expert artisans in the factory are most competent to prepare the crude earthy material, grind, compress, and fuse it into blocks having the semblance of teeth, perfect material for the hand of the artist. The error has been made by the profession in that it demanded of the manufacturer a finished product for the individual case, which is an impossibility. The artist, and he is the dentist, must take the product of the artisan and individualize it.

The manufacturer has, for convenience of marketing, arranged his stock of teeth in sets. These sets vary in number from two to twenty-eight teeth, and are of uniform color, that is, the color, tint and shade are the same in each of the teeth; while in nature the tint and shade of a set of teeth vary materially.

Shade and tint are technical terms of the colorist. *Shade* implies that a small amount of black is added to deepen the color, while *tint* is produced by the addition of white.

Dr. E. A. Royce, of Chicago, has called attention to the fact that the upper central incisors are the foundation tint of the teeth in a set, while in the laterals and cuspids the shading is progressive and then diminishes through the first and second bicuspids and first molar. The lower teeth follow the same rule, beginning with the centrals a little darker than the upper centrals.

The amount of shading in each of the classes of teeth will vary with the environment; that is, temperament, age, and the influences of waste and repair. Therefore for the manufacturers to attempt to supply, through the trade, teeth esthetically constructed for each individual case would result in a bewildering confusion. The artisans are doing well their part in supplying stock teeth, but the prosthetist must develop the esthetics, otherwise he is an artisan and not an artist. The operative dentist's claim to professional recognition is founded upon pathology; the prosthetist's professional claim is based upon esthetics; consequently he is, or is not, an artist.

Materials for Staining Teeth.—The supply houses of both this country and Europe have placed upon the market the necessary equipment for staining and changing the tint and shade of teeth. This equipment consists of a few colors (either primary or mixed colors), usually a fluid as an applying medium, a mixing spatula, brushes, and a mixing slab of glass or porcelain. As instructions for use accompany each outfit, it is unnecessary to consider the various kits.

The colors are mineral (metallic oxides) incorporated with a body of the nature of glass (sometimes called porcelain). They all fuse and form a glaze over the surface upon which they are applied. Therefore to use them to change the color of an artificial tooth to match the color of another as it comes from the factory is not their intended use. They are an overglaze and not an underglaze; that is, the color is on the surface, not under the surface. The various materials placed upon the market vary greatly in fusibility and durability. The rule is, and has been, invariably true in the past that the durability is in the inverse order to its fusibility. However, the last claimant for consideration (Lenox mineral stains) may be an exception to the rule.

It certainly is exceptional in some respects. As the fusibility of glass and porcelain products has been contingent upon the amount of flux (alkali) incorporated, this new material must be subjected to the test of time to prove its wearing qualities. The writer has tested the Lenox material with the Price pyrometer, and has found that it takes a very good glaze with an exposure of one minute at 1100° F., and that it resists the friction of the felt wheel and pumice stone. It is better glazed at 1400° to 1500° F. It is surprising that the material stands 2300° of heat almost as well as the White and Brewster colors, which require at least 2000° F. to give them a suitable glaze. The new product is ground exceedingly fine, and in that respect is a superior product. However, until it has been demonstrated that this new material resists perfectly the disintegrating action of the fluids of the mouth, the writer will place his faith in the higher-fusing materials.

Mixing Fluid.—The fluid used has no action upon the paint material; it is only a means for applying and retaining the powdered pigment. Water, gum-arabic water, oils—as cloves, poppy, lavender, and turpentine—also glycerin, are used. Water is the most unsatisfactory fluid named. Of the oils, that of cloves is excellent; its unctuous nature is its only drawback. Glycerin has recently been recommended by Dr. Royce, and it certainly is an excellent medium.

Technic.—The paint or stain is spatulated upon the slab with the chosen medium to the required consistency (thick for deep color, and thin for light tint) and applied to the alcohol-cleansed surface of the tooth with a soft pencil brush. It may be more evenly spread with a short stubby brush used as a stippler. Certain effects may be produced by a light wiping stroke of the finger. This will remove the color from the elevated portions and leave it in the depressions and grooves. Highly vitrified teeth may be much improved by spreading the color over the surface with a pencil brush and stippling with the ball of the finger. This produces the columnar crystalline effect of the natural tooth. The painted tooth is dried in a moderately warm place, then glazed at the required temperature.

Suggestions.—The tooth should not be handled with the fingers after cleansing with alcohol, but with clamping pliers attached to the pins.

The tooth or teeth while in the furnace should be placed with the face side upward; the pins, however, should not come in contact with the bottom of the furnace or heating slab. Place a quantity of finely crushed quartz in the bottom of the furnace, or upon the slab, upon which the teeth may rest, and also as a protection for the pins from too rapid heating, thus avoiding danger of checking the teeth.

To prevent blisters in the paint, heat up slowly. The slab or tray upon which the teeth are heated may be taken from the hot furnace and placed in a cooling muffle.

Coloring.—It should be remembered that there are but two primary colors in the artificial teeth, yellow and blue, but many tones (degrees of color) of these colors. The color of the various teeth is produced by shading, tinting, and blending. Therefore in staining teeth the primary color must be noted and an estimate made of the amount of shading a darker color will produce before producing the characteristic color upon the surface.

It is always easier to deepen the color of a tooth than to make it lighter.

The natural teeth are constantly growing darker with age, just in the ratio to the change in the natural complexion of the patient. This is due to the fact that the teeth belong to the dermal tissue and both are pigmented by the circulating fluids of the body. Therefore in coloring or staining the teeth they may be shaded a little darker than the natural ones and be less conspicuous.

The natural teeth are subject to many external coloring influences, as smoking and chewing tobacco or other drugs, discolored incipient decay or white or yellow spots from defective calcification of the teeth.

APPLIED ESTHETICS.

A few practical cases will suffice to elaborate this phase of the subject.

Fig 431

Fig. 432

Figs. 431 and 432 is the patient previously presented, laughing. Fig. 431 shows the gum of the gum-section teeth, although much retruded. The teeth are undersize and have

Fig. 433

Fig. 434

Fig. 435

the artificial appearance of their type. Fig. 432 shows another view of the contour as illustrated in Figs. 424 and 425 properly restored, and if the teeth are of suitable form,

FIG. 436

FIG. 437

FIG. 438

FIG. 439

size, color, and individualized, they appear like well-preserved natural teeth. If they do not harmonize in every respect the artificiality of the dentures is more conspicuous than in the old ones.

FIG. 442

Figs. 433 and 434 present two views of a patient; the one upon the left shows the upper of a gum-section set that had been worn for thirty years. The gum portion shows also the undersized, youthful appearance of the teeth. The lower teeth are entirely out of sight. The mouth is much better restored in the view upon the right. While the dentures in

Fig. 443

Fig. 444

Fig. 445

FIG. 446

FIG. 447

FIG. 448

Figs. 435 and 436 are not ones in the patient's mouth, they are almost duplicate.

Fig. 449

Fig. 450

Fig. 451

Figs. 437 to 442 show the patient and teeth constructed to the mouth of the Williams "Trubyte" teeth. The teeth were all stained except the upper second molars, which were left unstained to show the change produced by staining. The effects can be seen in the photos, but it is doubtful if it will be apparent in the half-tones.

Figs. 443 to 446 show different phases of esthetic restoration in continuous gum work. This is the completed case, the skeleton of which is shown in Figs. 356 and 357.

Figs. 447, 448 and 449 are views of a continuous gum upper and cast metal lower that have been doing service for some years. The dentures had been worn four years when the photos were taken.

Figs 450 and 451 are two views of a case, requiring a unilateral restoration, for a crescent-shaped face viewed from the front.

INDEX.

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